The EDISON ELECTRIC INSTITUTE BULLETIN

July
1954

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Electricity from Atomic Fuel
Dr. John R. Dunning

Peacetime Atomic Energy
Robert LeBaron

Nuclear Power and Utility Securities
Eldred H. Scott

Customer Relations
Henry B. Sargent

Treasury Financing
David M. Kennedy

Published Monthly by Edison Electric Institute

ELECTRICAL RESEARCH STATISTICS
THE ELECTRIC LIGHT AND POWER INDUSTRY

Current Statistical Data Covering 100 Per Cent of Industry

April, 1953-1954

SOURCE AND DISPOSAL OF ENERGY—MONTH OF APRIL

	1954	1953	%
NET GENERATION* (Kwhrs in thousands)			
By Fuel Burning Plants	26,925,166	25,922,695	+ 3.9
By Water Power Plants	9,910,160	9,704,742	+ 2.1
Total Generation	**36,835,326**	**35,627,437**	**+ 3.4**
Add—Net Imports Over International Boundaries	79,038	165,965	−52.4
Less—Company Use	124,626	129,569	− 3.8
Less—Energy Used by Producer	683,718	659,135	+ 3.7
Net Energy for Distribution	**36,106,020**	**35,004,698**	**+ 3.1**
Lost and Unaccounted for	3,220,970	3,489,976	− 7.7
Sales to Ultimate Customers	**32,885,050**	**31,514,722**	**+ 4.3**

CLASSIFICATION OF SALES

NUMBER OF CUSTOMERS—As of April 30			
Residential or Domestic	42,243,407	41,087,073	+ 2.8
Rural (Distinct Rural Rates)	1,630,945	1,578,066	+ 3.4
Commercial or Industrial:			
Small Light and Power	5,892,947	5,698,882	+ 3.4
Large Light and Power	272,532	265,611	+ 2.6
Other Customers	160,746	157,293	+ 2.2
Total Ultimate Customers	**50,200,577**	**48,786,925**	**+ 2.9**
KILOWATTHOUR SALES—During Month of April (Kwhrs in thousands)			
Residential or Domestic	8,942,105	8,003,947	+11.7
Rural (Distinct Rural Rates)	755,806	850,490	−11.1
Commercial or Industrial:			
Small Light and Power	5,801,634	5,390,801	+ 7.6
Large Light and Power	15,865,211	15,760,868	+ 0.7
Street and Highway Lighting	310,814	286,996	+ 8.3
Other Public Authorities	763,406	734,600	+ 3.9
Railways and Railroads:			
Street and Interurban Railways	217,004	240,187	− 9.7
Electrified Railroads	179,946	195,937	− 8.2
Interdepartmental	49,124	50,896	− 3.5
Total to Ultimate Customers	**32,885,050**	**31,514,722**	**+ 4.3**
Revenue from Ultimate Customers (Thousands)	**$585,598**	**$553,005**	**+ 5.9**

RESIDENTIAL OR DOMESTIC SERVICE

AVERAGE CUSTOMER DATA—For 12 months ended April 30			
Kilowatthours per Customer	2,415	2,226	+ 8.5
Average Annual Bill	$65.69	$61.44	+ 6.9
Revenue per Kilowatthour	2.72¢	2.76¢	− 1.5

* By Courtesy of the Federal Power Commission.

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The objectives of the Edison Electric Institute are:

The advancement in the public service of the art of producing, transmitting, and distributing electricity and the promotion of scientific research in such field.

The ascertainment and making available to the members and the public of factual information, data, and statistics relating to the electric industry.

To aid its operating company members to generate and sell electric energy at the lowest possible price commensurate with safe and adequate service, giving due regard to the interests of consumer, investor, and employee.

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CONVENTIONS AND MEETINGS

1954

SEPTEMBER

13 EEI Purchasing and Stores Executive Committee, Cleveland, Ohio.

14-17 EEI-AGA Accounting Division Organization Meeting, Hotel Cleveland, Cleveland, Ohio.

16-18 36th Annual Meeting of Public Utilities Association of Virginias, The Greenbrier, White Sulphur Springs, W. Va.

20-21 EEI Accident Prevention Committee, Benjamin Franklin Hotel, Philadelphia, Pa.

27-29 EEI Industrial Relations Committee, Round-Table Conference, Palmer House, Chicago, Ill.

27-29 EEI Meter and Service Committee, Leland Hotel, Springfield, Ill.

29-Oct. 1 EEI-AGA Tax Committee, Brown Palace Hotel, Denver, Colo.

OCTOBER

4- 5 EEI Prime Movers Committee, DeWitt Clinton Hotel, Albany, N. Y.

6 Area Development Committee Organization Meeting, Hotel Statler, Cleveland, Ohio.

6- 8 Indiana Electric Association Annual Convention, French Lick Springs Hotel, French Lick, Ind.

7- 8 Area Development Workshop, Hotel Statler, Cleveland, Ohio.

1954

7- 8 EEI Transmission and Distribution Committee, Sir Francis Drake Hotel, San Francisco, Calif.

10-13 Controllers Institute of America, Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

11-12 EEI Electrical Equipment Committee, Hotel Statler, Hartford, Conn.

11-13 AGA Convention, Accounting Headquarters, Haddon Hall, Atlantic City, N. J.

18-22 ASCE Annual Convention, Hotel Statler, New York, N. Y.

21-22 EEI Advisory and Executive Committee, Netherland Plaza Hotel, Cincinnati, Ohio.

28-29 PIP Workshop Conference, Chase Park Plaza Hotel, St. Louis, Mo.

NOVEMBER

8-12 NARUC Convention, La Salle Hotel, Chicago, Ill.

18-19 EEI Industrial Relations Committee, in conjunction with the North Central Electric Association, Minneapolis, Minn.

29-30 EEI Prime Movers Committee, Astor Hotel, New York, N. Y.

DECEMBER

16 EEI Industrial Relations Committee, EEI Headquarters, New York, N. Y.

Wisconsin Utilities Association Accountants Hold Annual Meeting

WITH 135 accounting executives attending, the Annual Convention of the Accounting Section, Wisconsin Utilities Association, was held at Lake Delton, Wis., on June 27-29.

Roy F. Miller, Vice President and Treasurer, Northern States Power Co. (Wis.), was elected Section Chairman for the coming year. Fred O. Harbrecht, Assistant to the Vice President and Controller, Wisconsin Electric Power Co., was named Vice Chairman.

Speaking at the convention's general session, Harold P. Taylor, President, Wisconsin Utilities Association, stated that there is no limit to what the industry can contribute to national prosperity if unfair competition from tax-exempt Federal power projects does not intervene.

He described the preference clause as an "injustice to customers of investor-owned utilities and one which would offend the sense of fair play of the American people if they clearly understood it." What the preference clause actually does, he continued, is to "compel 80 per cent of the people of this country to contribute toward paying the electric bills of the remaining 20 per cent."

But three factors give evidence that there is no limit to the future market of utilities, Mr. Taylor said. He named these as a predicted population growth of 45,000,000 by 1974, the desire of the American people for ever higher living standards, and the need for increasing mechanization and heat applications in industry.

As to the last factor, Mr. Taylor cautioned the accountants to keep abreast of atomic power developments "because the investors in securities are anxious to know what effect the proposed new fuel will have on future financing."

Mr. Taylor pointed out that the probable first use of atomic energy in the industry would be as "a substitute for the heat now used in generation by steam power plants." "But only about 10 or 12 per cent of an electric utility's plant investment in Wisconsin is in the boiler room and fuel handling facilities," he continued. "The evidence to date indicates that when and as atomic fuels become economically feasible they will supplement our present fuels by being put in new plants rather than to replace present heating facilities."

George P. Steinmetz, Commissioner, Wisconsin Public Service Commission, and J. H. Mikula, Milwaukee Gas Light Co., also addressed the general session.

The second day of the convention was devoted to committee meetings and technical reports.

The EDISON ELECTRIC INSTITUTE
BULLETIN

Prospects for Use of Atomic Energy in Generation of Electric Power

Dr. John R. Dunning
Dean of Engineering, Columbia University

An address before the 22nd Annual EEI Convention, Atlantic City, N. J., June 3, 1954

IN one sense a year is too short a time to report back to the Institute on the status of any particular field. But, on the other hand, the rate of progress during this last year, the growth, the expansion toward realization of our whole atomic energy development and production program have been so great that perhaps the demonstration of the latest versions of thermonuclear weapons in the South Pacific, which are still rumbling in many different fashions around the world, do set the stage for a real reappraisal of our whole future in the atomic energy field for peacetime applications.

Having built up great nuclear facilities, many of which are just now coming into production and will come in during the next year or two, we have achieved the base for an enormous weapons production. At the same time, we have achieved a solid base for a real expansion of our atomic power industries.

DR. JOHN R. DUNNING

Weapons and Power Not Competitive

There is no reason to think of these two—nuclear weapons and nuclear power—as competitive, but very properly they should be considered as being supplementary and indeed very vital that they should be together in the future. For just as the electric industry in its great generation of power is probably the best index of this country's defensive and offensive strength in war—because it supplies the energy that makes our total production system possible—so a great development in civilian atomic power industry will provide the same kind of support to our war or defensive strength.

Indeed, the only sound way in which we can proceed in the future is to have our military strength in the normal fashion be an adjunct or a consequence of great civilian strength if we are to maintain our American tradition that has made this country strong in the past.

There is another side to this whole picture that I wish to go into a little bit, that you have all been studying in its many facets for a long, long time. It is the justification for a growing atomic power program in the hands of your industry. Starting 75 years ago when Thomas Edison developed the electric light, and then the first power stations where coal consumption of the order of 20, 30, and, I am told, even as much as 50 lb per kilowatt, was not uncommon, on down to the present day when many of your plants consume something like .75 lb per kilowatt, you have seen an enormous change in the amount of coal or energy used per kilowatt produced.

You have seen at the same time an enormous growth in the consumption of electric power per person and likewise, of course, a corresponding growth with our population of the total produced. Your own Electric Power Survey Committee has extrapolated to 1975 and shown that the power industry will certainly double within the next ten years in capacity and probably on any reasonable basis by 1975 reach three or four times its present generating capacity.

Key to Modern Civilization

Electric power is a major part of the total energy consumption that is the key to our modern industrial civilization. Coal, oil, and water power have been the bases of this economy up to now. Though there have been many continuing series of projections as to the available reserves of all of these energy sources, differing estimates and questionable extrapolations into the future, there is no question that while we are enormously expanding our energy utilization on the one hand, in many areas our fossil fuel reserves in the form of easily and economically recoverable supplies are beginning to show some loss of strength.

In England fuel costs have continued to rise, the production, in effect, dropping with a clearly growing fuel deficit. Even in this country we have

seen certain coal mining areas beginning to run a little low. We have seen a growing necessity for importing increasing amounts of crude to supplement our existing oil production.

Table I is an energy reserve summary, which, like all of such summaries, must be taken with a grain of salt. Nevertheless the relative figures do represent indices as to how we may look at the problem of future energy reserves. At the right the important points are estimates of apparent fossil fuels: oil shales, crude oil, natural gas, and coal, which in the particular units used total 80 x 10^{18} for conventional fuels.

In terms of our present estimated supplies of visible uranium, assuming 1-to-1 breeding, there again is a series of estimates. This particular figure, largely from Palmer Putnam under AEC auspices, comes out with a total of uranium fuel and of thorium fuel. However, some of us question the value for thorium because we suspect if you look for thorium the same way as we are now searching for uranium, thorium would probably be a good deal larger than the indicated visible supply.

TABLE I—WORLD RESERVES OF FOSSIL FUEL AND NUCLEAR ENERGY

FUEL	WORLD RESERVES	SOURCE OF DATA	UNIT ENERGY	TOTAL ENERGY BTU
Crude Oil	610 billion barrels	Weeks and Moulten	6.4 x 10^6	35 x 10^{17}
Natural Gasoline	11.5 billion barrels	Am. Petroleum Inst.	6.4 x 10^6	0.74 x 10^{17}
Shale Oil	620 billion barrels	Bureau of Mines	6.4 x 10^6	40 x 10^{17}
Natural Gas	560 trillion cu ft	Am. Gas Association	1000 Btu per cu ft	6 x 10^{17}
Coal	3482 billion tons	Bureau of Mines	13,500 Btu 14,000 Btu 9,000 Btu	722 x 10^{17}
Total Conventional				80 x 10^{18}
Uranium	25 million tons	Raw Materials Div. of AEC	3.5 x 10^{10}	1700 x 10^{18} at 1-to-1 breeding
Thorium	1 million tons	Raw Materials Div. of AEC	3.5 x 10^{10}	71 x 10^{18}
Total New Fuel				18 x 10^{20}

Abundant Reserves

The important conclusion from the data is that already, with only about ten years of any appreciable searching for uranium, we have completely reversed our position held in the immediate postwar period when most so-called experts were saying we couldn't possibly have enough uranium to build an atomic power economy. In this short space of time, there has come general agreement that our uranium reserves constitute the major fuel reserves in the world for the future. A figure something like 25 times as much energy in uranium as in coal, oil, and gas is now usually quoted.

There, again, this figure has to be viewed as a tentative figure. It wouldn't surprise some of us too much to find there were 100 times as much energy in the form of atomic fuels as future progress develops in atomic energy release methods, atomic fuel recovery methods, raw-material prospecting, and so on down the line.

The important lesson is that our future energy reserves are abundant in the atomic field. Indeed, they are many, many times that of our conventional fuels. As we look forward to 1965, '75, '85, up to the year 2000, no matter how you look at it, you are going to have to turn to uranium and atomic power to meet your increasing energy deficits from conventional sources.

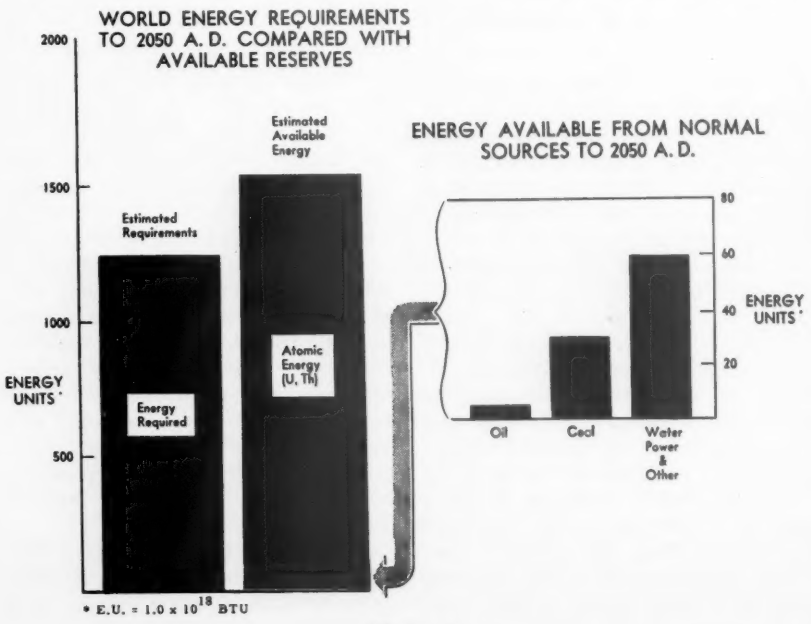


Figure 1

Projection of Future Utilization

Fig. 1 gives a rough projection on future utilization. It is a little crude, but the Power Survey Committee's curve extrapolated to 1975, while this continues up to the year 2000, only 50 years, suggesting that the estimated energy requirements will run according to the block on the left.

For the amount of available energy that you can extrapolate (and this is exceedingly crude, of course), look at the large block on the right.

But no matter how we look at it, the amount available from coal, oil, and water power and other sources can only constitute about this little gray portion at the bottom.

This, of course, is a world picture rather than for the United States alone, for you recognize that whereas our power generation is now 40 per cent of the world total, the power available per person over the world as

a whole is exceedingly low at present, because we constitute less than 7 per cent of the world's population. There will be an enormous growth in the energy demands per person over the world as a whole that percentagewise must be very much larger than ours here, because we are already up quite high on the curve.

This energy deficit, no matter how you extrapolate it, must inevitably mean at least this conclusion: to meet the world's rapidly expanding energy requirements you have no other recourse than to turn to atomic fuels in the course of these next decades. Exactly how this rising curve will go, will move forward, could be discussed indefinitely. Nobody is wise enough in this world to predict very accurately the course of these curves. I am simply laying down some general conclusions and not trying to give any specific data, because no one is possibly good enough or has an effective enough plastic crystal ball to do it. An inescapable conclusion is that we have to look forward to increasing power production from the atomic power sources as we look to the future.

Basic Process Steps

Let's look a little more deeply at what lies behind atomic power utilization. Fig. 2 is taken from an Atomic Energy Commission report and symbolizes basic process steps. The upper left-hand corner represents uranium being taken out of the ground—for example, in our Colorado Plateau area, the Belgian Congo, or in Canada—in the form of various minerals or uranium extracted from the phosphate ores or perhaps even from the shales that we are investigating now. We have a rather large project at Columbia on recovery of uranium from shales, and it looks rather interesting for the future. At least many new sources of uranium are opening up.

Uranium must go through various processing and beneficiating steps as shown at the left, following the dotted line. Fortunately today, because of enormous build-up of the military atomic weapons field, we have gas diffusion separation plants at Oak Ridge, Paducah, and now at Portsmouth getting under way, which constitute an enormous atomic fuel production system.

These diffusion plants produce uranium 235, the concentrated starting atomic fuel in nature, but only 7/10 of 1 per cent, unfortunately. Even so, they produce it at remarkably cheap costs, as the Commission's figures of sometime ago show. (The AEC has not released any recent cost data for high purity atomic fuel.) If pure uranium 235 came out of the gas diffusion plant in the cycle shown, it would generally be said to cost somewhere around $8,000 or $9,000 per pound over-all. However, such cost figures may be adjusted by improvements in production.

U-235 in high concentration is, in effect, the equivalent of something like $6 a ton for equivalent Btu content cost but will be lower for slightly enriched U-235 as now projected by some atomic power plant design groups. The total picture is not that simple, unfortunately, but, nevertheless, such cost figures serve as a base on which to project future atomic energy costs.

The enriched U-235 diffusion-plant cycle, because we now have such large production facilities in this country, is now incorporated into every atomic power development. I think it is safe to say that today essentially no one talks about using natural uranium anymore, and that atomic power plant design is thereby much improved.

From the diffusion plant, atomic fuels go into some kind of a fuel preparation section equivalent to the coal pulverizing section of a conventional plant but a good deal more complicated, unfortunately. Its nature depends on how the fuel is to be used —whether the fuel will be fabricated into solid fuel elements as a metal or alloy and encased in protective metal covering, or whether it will be used in the form of powdered material or as solutions or as slurries as in the homogeneous types of reactors.

The fuel goes then into the reactor —and as heat to the power-plant cycle, which is essentially conventional in all the designs so far. Finally, from the reactor, we see another phase of atomic power systems that constitutes a distinctly important capital and operating cost factor: the reprocessing of the partially spent uranium fuels and whatever breeding blankets of fertile materials may be used.

Two Essential Factors

There are two essential factors important in all atomic power plants that represent crucial points upon which real emphasis must be placed. One is that the initial, atomic fuel inventory capital investment cost in all of the various types of power systems now under consideration may range all the way from $1,000,000 to $40,000,000 for the initial capital cost of the fuel; and, second, the reprocessing plant, shown here as a cycle operation in which the fuel is burned partially and then has to be purified and recycled back into the system, is in general ranging from $3,000,000 to perhaps

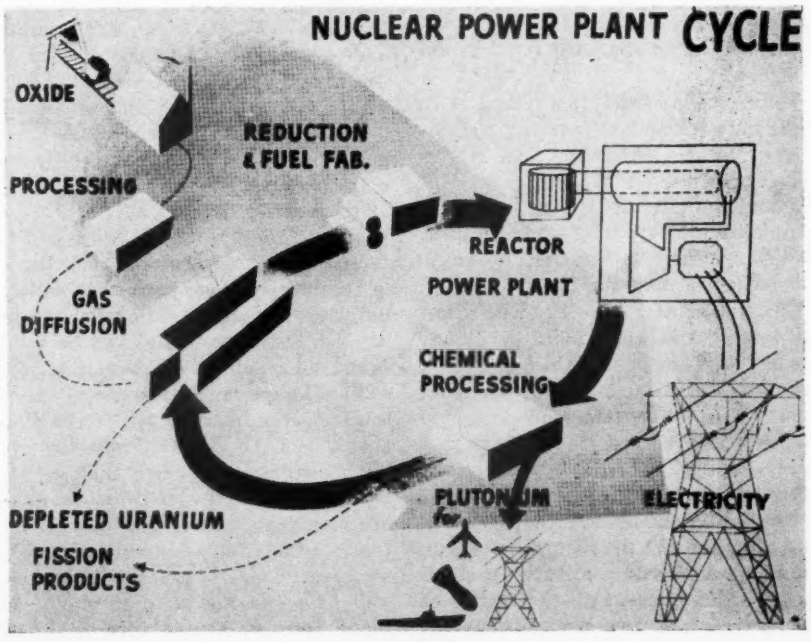


Figure 2

$25,000,000 in capital costs for the various design estimates thus far. These major items differing from conventional plants are soft points that require a great deal of work in the future.

In addition, of course, we have the general question of the fission products and the plutonium (or U-233) as by-product materials, which may or may not have by-product credit beyond that of normal fuel.

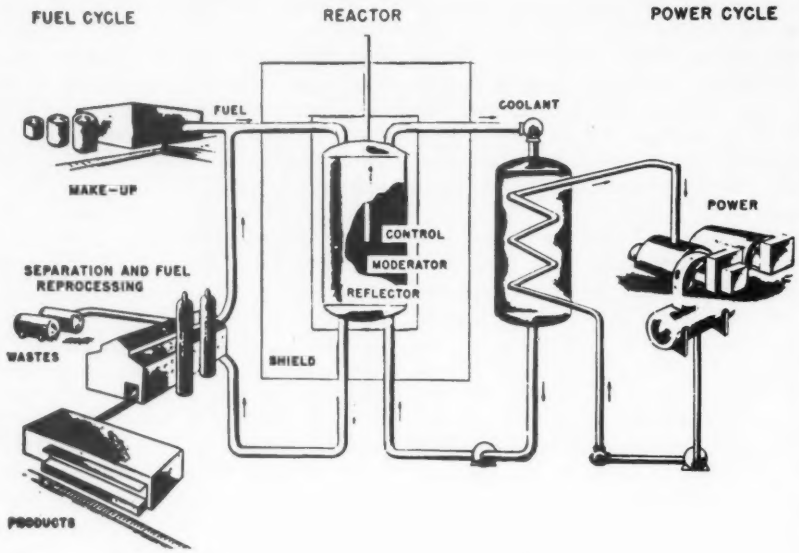
Two Lines of Approach

Fig. 3 is another schematic of a nuclear power plant, slightly more in detail, which over at the left shows the fuel input system, then the reactor with its controls, the moderator in some cases, depending on the type of reactor, and the reflector and shield as part of the cycle. There are two major lines of approaches at this point. Almost all designers so far are thinking in terms of a secondary heat interchange system with some kind of conventional steam boiler powered by a coolant in the secondary circuit from the reactor and then, of course, on to the power cycle.

There is, on the other hand, a rapidly growing interest in the self-boiling type of reactor in which the water is boiled directly in the reactor and does not go through a secondary coolant interchanger system. This permits consequent reductions in capital cost and simplification but with some other disadvantageous factors, such as possible radioactive carry-over, which some of the experts feel are important.

Here, again, the fuel preparation fabrication and fuel inventory on one hand and the separation fuel reprocessing plants on the other are the major capital items that must be minimized if we are to drive these over-all atomic power costs down to or below conventional plant costs.

There are now some 12 or so more-or-less formalized industry study teams that have now grown out of an original four—and actually a good many more study teams are scattered quite widely all over the country that are perhaps not quite so formally recognized. During the last three years of study by our industry colleagues, for the first time, we began to get an evolving picture—preliminary, it is true—as to the course of design costs as we project into the future.



Nuclear Power Plant System

Figure 3

Clearly we have very wide differences of opinion even yet, but this important point emerges clearly. No one today is questioning if atomic power can be developed. That has long since been answered affirmatively. Everybody agrees that atomic power can be generated, technically. The only questions now arising are what are the capital and operating costs going to be; which of the four or five at least basically different kinds of reactors are really going to be the ones most useful and effective economically; and what is the future schedule of atomic power plant development and adoption going to look like? These are the three main areas of differences of opinion at the present time.

Just to highlight a few of these differences and not to get into their highly technical phases, there is a widely differing school of thought as to whether fuel elements should be solid fuel, canned in stainless steel, zirconium, or perhaps some of the more exotic materials, or whether the fuel should not be solid. Some say we might as well recognize that as we run up in power to temperatures that are almost unlimited, limited only by the materials in the atomic furnaces, we have to face whether we might as well have the fuel in fluid slurry or liquid form or molten form right at the start.

Since the whole body of experience up to now has evolved around solid fuel elements, there is not much question but what the first atomic power plants, as indeed the submarine power plants and the Westinghouse Duquesne units, will have solid fuel elements. Whether the rapidly growing interest in having homogeneous fluid type fuels will continue and bring that system in rapidly during this next five years or ten years, and whether they will eventually replace the solid fuel elements, is a matter for considerable argument. Personally, I have always liked the homogeneous system in principle, but there is no question but that the solid fuel elements work fairly well and they will undoubtedly find their own level economically and technically.

High Cost of Fuel Preparation

One reason why the solid fuel versus liquid fuel situation is serious is the very high cost in the fuel preparation and fuel processing sections, which are really practically the major end on which we need some hard work. In principle, a little 1-in. cube of uranium, which is the equivalent of 2 or 3,000,000 lb of coal, will keep any one of your largest single power plants in any of your systems going for about a day. The amount of ashes, the amount of spent fuel to be processed,

even if you process it once a day, would, therefore, in principle, be very little larger than this piece. This is about the physical amount of fuel you would have to reprocess per day if you reprocessed all the spent fuel. Homogeneous-type reactors with liquified fuels are not presently in an advanced state of development, but eventually the greater intrinsic ease of continuous fuel reprocessing should be strongly in their favor.

Actually, these atomic fuels must normally be diluted. Fuel inventories generally are going to have to be up in the tens or generally in the hundreds of pounds in order to have sufficient dilution and, therefore, heat transfer surface to be able to get the heat transferred to a coolant with temperatures that are not beyond the capability of existing materials to withstand. But the problem of reprocessing and handling is not one of handling thousands of tons. It is really more a matter of handling a relatively small amount of material—handling it effectively and cheaply with due regard for safety and radiation and adequate removal of fission product "poisons."

Reprocessing Cost

There are many new developments coming along in the techniques of reprocessing, and, while no one can say that these capital and operating costs are down adequately at present, the program almost certainly points to the fact that within two, five, or certainly ten years the over-all reprocessing cost is going to be reduced by very great factors.

This must happen if atomic power generation on a large scale is to become economical. The actual problems are not excessively difficult, but rather it is a matter of combining some good ideas with well engineered systems and not setting the purification specifications higher than definitely required.

Which Reactor?

In addition to this question of solid versus homogeneous fuels, there is the whole question of fast reactors versus thermal reactors or the intermediate type. Here again there are several schools of thought, and each school has some good points in its favor. The thermal reactors are the ones we have had most experience with now. All of them use water, graphite, or in some cases heavy water as moderators with beryllium as reflector or structural element constituents. They are largely thermal in that the neutrons are largely slowed down to ordinary thermal speeds.

On the other hand, the highest efficiency from the standpoint of breeding new fuel obviously comes when you have fast reactors with very little moderator around and the neutrons have essentially their initial full speed. These reactors will undoubtedly give higher breeding gains, and if we wish to emphasize the by-product production of high-grade plutonium for weapons as one facet of our evolving atomic power energy economy or if we wish to emphasize the fuel credit and by-product sales of plutonium as part of our evolving economy, then the fast breeder definitely will have a real place.

Let me paint the picture this way: the most expensive possible way we can utilize atomic fuel, according to present science and technology, is to use pure uranium 235, to which, as I said, you might attach an intrinsic price tag of $6 per ton per equivalent Btu. However, in none of the reactors do we have 100 per cent burnup; 50 per cent burnup under the present conditions is about as much as we can hope for. In the present type of solid-fuel reactors we would be very happy to see somewhat more than 1 per cent of the fuel burned up or converted before a reprocessing job is done. This is currently one of the serious factors that must be improved if costs are to be brought down.

If you consider this U-235 material as being half burned in a conventional reactor, in pure form, then you will come up generally with equivalent fuel costs compared to coal—somewhat higher than coal—something above 1.5 mills per kilowatthour. On the other hand, if we are able to breed and produce more new fuel than we burn, or produce at least some new fuel in addition to what we burn, then in the range from pure uranium-235 with zero breeding up to unity breeding (1 to 1), which means you burn exactly as much fuel as you produce, we have essentially equilibrium and no high-grade U-235 needs to be added. The only fuel costs are the inexpensive fertile materials either normal U or depleted U-238 (or thorium in case a thorium-U-233 cycle is used). In the range from zero breeding to unity breeding in the so-called conversion range, there is a big range to play with in terms of sharply reduced fuel costs from conventional fuels.

Extreme and Intermediate Positions

If, for example in Fig. 4 you burn even one pound out of 100 of uranium, you begin to make substantial gains in your apparent fuel costs. This figure is one which I think comes from

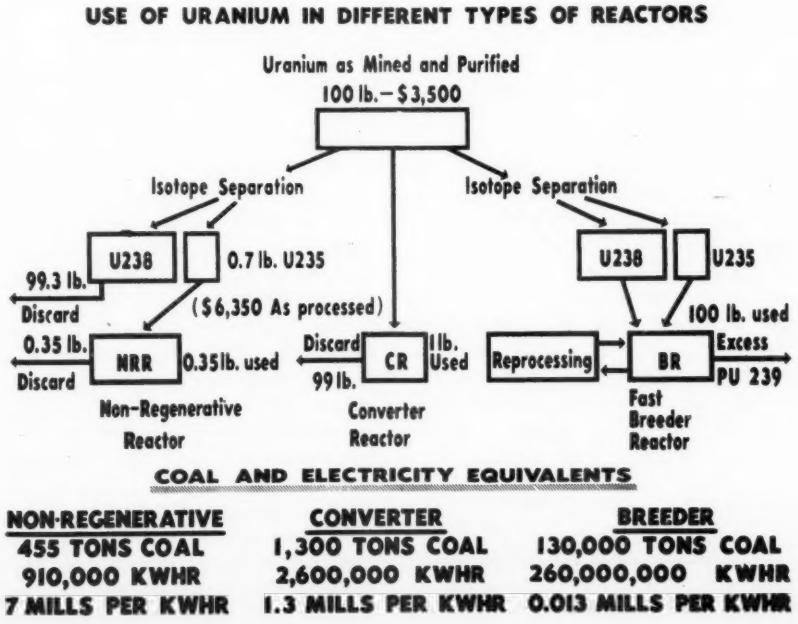


Figure 4

the Detroit Edison-Dow group and tells part of the story graphically. Start at the top with uranium as mined and purified somewhat fictitiously priced at $3500 for 100 lb, and go through the three different channels. At left, uranium 235 in pure form is used, straight out of the gas diffusion plant. In the center line, which represents the converter type, the ratio shown is 1 out of 100 of the total uranium charge being burned and converted to plutonium or U-238. Represented at right is a unity breeder reactor in which, in effect, all of the uranium in an extreme case can be burned because the U-235 in the reactor may convert the uranium-238 to plutonium and through the reprocessing plant that is shown there at the right, you can, in principle, recycle all of the uranium and, in effect, burn it all. If the breeding gain is above unity, an excess plutonium will be produced.

These illustrate what might be called the two extreme positions and the intermediate position that lies in between. But you notice, if a little calculation is made in the first example, that there is a 50 per cent burnup. The full costs come out 7 mills per kilowatthour. But if you use even only 1 per cent of the uranium by conversion, your fuel cost drops to 1.3 mills per kilowatthour.

I believe it is safe to say that the typical fuel costs averaged over the industry as a whole in this country range between 1 and 5 mills per kilowatthour. Some of you may think you are getting a little under that. But if you stretch the cost range from here to other countries, the world as a whole is paying all the way from 1 to perhaps even 30 mills per kilowatthour for its fuel costs.

For atomic fuels there is a wide range at our disposal. We can go from 7 mills per kilowatthour with no breeding whatsoever. We can go to 1.3 mills if we burn 1 lb out of 100 and discard 98—in effect, the fuel costs will drop in half again. If we burn 5 lb, even, out of 100, the fuel costs will drop down to some tenths of a mill range—well below any conventional fuels. Or if you go clear on over and really burn all of the uranium, your effective fuel cost goes down into hundredths of a mill range.

The Important Factor

The real question we are up against as a matter of policy is where in this broad range do we want to operate from the fuel-cost standpoint. It has been to a fair degree my feeling, although there are widely differing opinions, that once you get your fuel cost down below 1 mill, you get down to where you are talking about tenths of a mill, that already this is so small compared to our present fuel cost that the primary emphasis for the time being should be turned elsewhere, not so much to reducing further what is almost a negligible fuel cost. The important factor becomes finding ways to reduce capital investment and to reduce operating costs.

Characteristically, in this country perhaps we haven't been as wise as we should be, but starting with the 20 or 30 lb of coal Edison used to shovel in per kilowatthour, we have generally tended initially, in starting an industry, not to worry too much about fuel efficiency. Let's go ahead and get the industry started and then start chiseling our losses and increasing the efficiency as the industry progresses.

Whether we should come the whole way toward above-unity breeding now or should deliberately right now look at these economic and technical factors is a matter of wide difference of opinion. Indeed, the thing that gives me the most confidence in this whole atomic power field is that very able people differ widely on what is the best way to do it, and each one of them can make a very good case. This means that this field is wide open for all kinds of technical developments along a whole series of broad fronts, ranging from the mining operations through to fuel technology, through to reactor and heat exchange technology, and through to full utilization and reprocessing end as well.

So, when you have an industry that is just getting ready to go over the hump, that has so many interesting aspects of great technical and economic promise, with the end goal that at least the intrinsic fuel costs can be brought down to almost any level you wish to bring them, you have an industry with great potentialities, beyond any question.

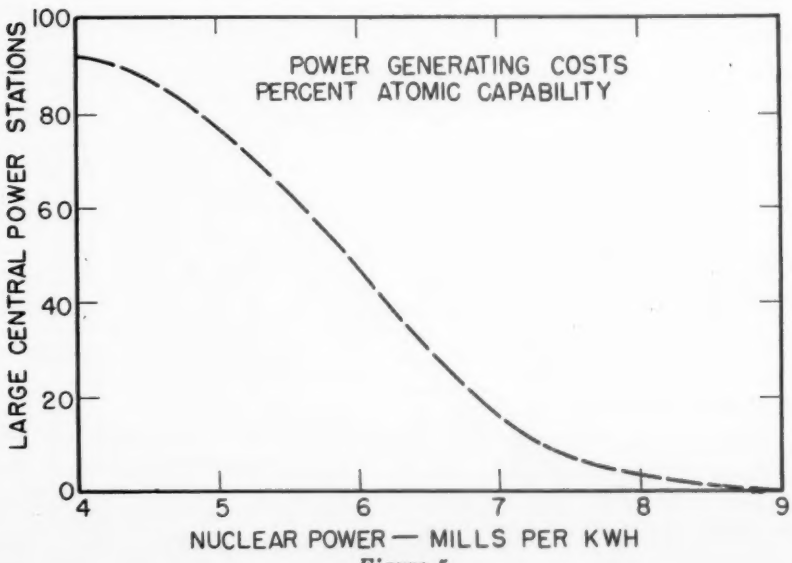


Figure 5

Generating Costs

It is true that up to the present time all of the estimates of costs have had very wide margins of error and have all looked very high and very properly so. The next chart, Fig. 5, gives us a picture of generating costs that have come from a number of different industry sources and AEC, a composite of your newest, largest central power stations generally above 100,000 kw, as to what the indicated generating costs in mills per kilowatthour have been in these last few years. Again, individual plants cover a wide range, but this is more or less a composite of the industry. Very few of your new large central power stations are exceeding 8 mills; 9 mills is about the absolute ceiling.

Generating costs have ranged down, some say or claim, to 2-mill or 3-mill range. I didn't extrapolate the chart below 4 mills here, deliberately, because I wanted to keep the atomic

power cost in a reasonable competitive position rather than give the illusion that anyone should envision about .1-mill costs for atomic power generation.

So far it is clear, then, that atomic energy, if it is going to be competitively economical, has got to get into the range below 8 mills, and, if it is going to capture anything like 50 per cent of the market, assuming the present dollars mean anything five and ten or 20 years from now, you are going to have to talk in terms of our present dollars at least of something like 5- or 6-mill nuclear power or you are not going to be in the competitive range. Because capital and operating costs appear to increase less rapidly with size of atomic plants compared to conventional, economic atomic power means emphasis on very large units. This is an unfortunate factor in getting the atomic industry going rapidly as a progression from experience with smaller units.

Steadily Increasing Fuel Costs

So, these are the problems that atomic power faces. It faces this problem of competitive power generating costs against a backdrop of steadily increasing fuel costs in terms of coal and of natural gas. The price of natural gas out of the Texas fields in the last five years has been going up pretty steadily. It certainly gives one pause as to what will happen in the course of the next ten and 25 years. Our specialized demand for gas will continue to increase and, at the same time, our domestic production is certainly not going to be able to meet our total fuel demands.

Similarly in the case of coal. While coal use is a little down now because of the decrease in railroad and domestic home use, it is nevertheless clear that the electric industry is steadily picking up the lead that coal lost through the railroads and that within ten years or so coal consumption, because of the increase in power generation, will be appreciably above the present.

Similarly if you look ahead 20, 30, 40, and 50 years, coal consumption will steadily rise, unless we find ways of getting alternative fuel supplies. One way of looking at this is that your conventional fuel costs are bound to rise considerably over the next 25 years to 50 years and that unless you have some competitive fuel coming in, you won't have any brake on the rise in fuel prices. So at least one way to look upon atomic energy is as a brake on conventional fuel costs.

TABLE II—NUCLEAR POWER PLANT COMPARISON

	Boiling Reactor Plant	Coal Plant
Physical Plant	$195/kw	$140/kw
Land	2	2
Engineering	15	11
Start Up	14	7
Nuclear Fuel Inventory	17	
Total Investment	$243/kw	$160/kw

Atomic Power Cost Estimate

Table II is one that we will blame on General Electric Co., one that Frank McCune presented at a recent Atomic Industrial Forum meeting in Washington. This is one of the more optimistic of the present flurry of more favorable cost estimates of atomic power. I should remind you that the reports of the four major study teams, which reported to the Commission a little over a year ago, came out with typical cost estimates on atomic power installations per kilowatt, ranging from roughly $500 or $600 per kilowatt installed down to about $300 per kilowatt. Those were the first round industrial study estimates.

I should also point out that for certain types of purposes as much as $1000 per kilowatt was quoted. This looked completely out of reason, but, while very little has been published as yet and is openly available, these cost factors have been in most instances steadily chiseled down by new engineering studies in the field. The particular type plant that General Electric Co. used as a cost base, and was willing to use publicly, was a "self-boiling reactor" plant, which means that there is no secondary heat exchanger incorporated. The steam is simply boiled in a reactor directly and uses slightly enriched uranium 235 fuel with some degree of breeding conversion in this intermediate range that I was talking about.

There you come out on a comparative basis of atomic versus conventional with a physical plant cost of $195 versus $140 per kilowatt. Other factors, including nuclear fuel inventory ($17,000,000 in this case), start-up cost, engineering, etc., are generally all a little higher, and we wind up with $243 per kilowatt versus $160. This is a distinct improvement over atomic costs estimated two years ago. I should, however, point out that this does not and many such estimates properly do not include the reprocessing fuel plants as part of the capital cost and, therefore, it may be just a little too good over-all. At any rate, it serves as an example of the trend toward better comparative costs for atomic power.

TABLE III—NUCLEAR POWER COSTS

	Boiling Reactor Plant	Coal Plant
Fixed Charges	4.65 mills/kwhr	3.0 mills/kwhr
Operating Cost	.70	.5
Fuel	1.35	3.4*
Total	6.7 mills/kwhr	6.9 mills/kwhr

* Coal at 35¢/million Btu.

Table III concerns the same plant carried through by GE, and it illustrates the significant cost differences between atomic and conventional plants. The fixed charges of the atomic plant do appear higher because of capital investment costs being higher. The operating costs are shown slightly higher, but the important saving really comes in the fuel where, by using a partial breeding, a partial conversion, fuel costs are brought down to about a third or the order of 30 per cent to 40 per cent of existing conventional fuel costs.

Apparent atomic fuel costs depend again on the degree of breeding you choose to take in your plant, but basically, whether you disagree or not with McCune's particular type of reactor, these charts begin to show in an atomic power plant capital and operating cost system where we can make progress, where the soft points are, and what the trends are.

Estimate of Atomic Power Use

Fig. 6 illustrates another line of approach. During the last few years, I have been asking virtually everybody to draw me a curve, estimating atomic power use from the year 1950 to the year 2000. I have tried to get estimates as to the percentage of new capacity that would be atomic.

What the upper curve in Fig. 6 represents is really a composite extrapolation of Institute figures plus a good many independent power company estimates on what total electric power generation is going to look like over

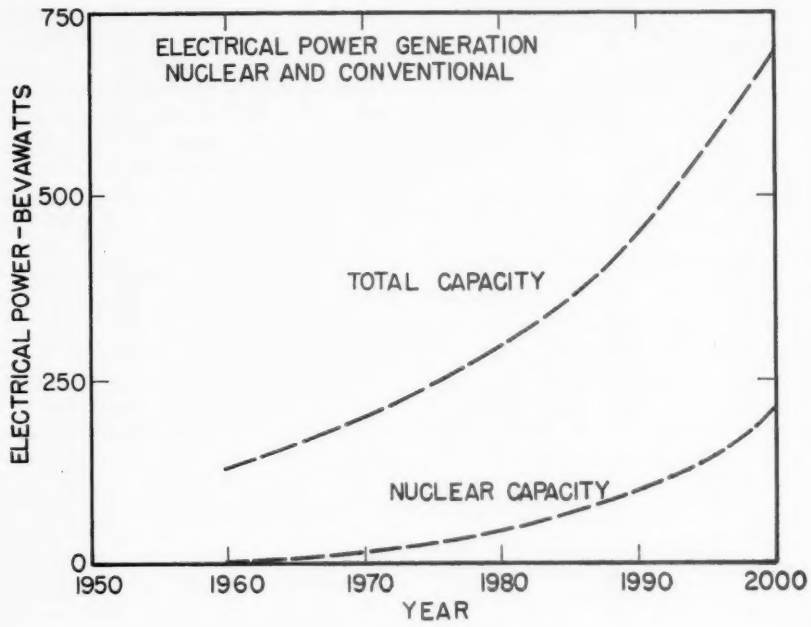


Figure 6

the next 50 years. What I really did was take a rough average of series of curves. They are not official, of course.

From the most conservative to the most optimistic of the nuclear power estimates, the average indicates that atomic power will perhaps be a small but definite percentage in 1960, six years from now, maybe a few per cent, at most. Atomic power will become appreciable by another ten years and may be something like 10 per cent of our total capacity in 1975, roughly 20 years from now. The curve from there on gets very questionable, of course. At least there is no doubt but that there is a continued and growing feeling, as we look into the future, that the percentage of capacity in nuclear power will grow steadily and that the general trend is much more optimistic today than one year ago.

Convenient New Term

I should point out that I used a new term in these charts, although someone must have used it before. The term "bevawatts," "billion watts," was introduced because I got a little tired writing 750,000 mw or 750,000,000 kw, and so on. The purists may not quite agree on this usage, but in the nuclear field we have been using terms like "bevatrons," and so on, to express the billion range for convenience. If you are going to plot rapidly rising factors like generating capacity to the year 2000, somebody had better start using the billion figure, otherwise you get too tired writing zeros.

Fig. 7 is a differential curve that really shows the new capacity, the annual increase in capacity taken from these same estimates, showing that the total increase is going to go up somewhat along those lines and that nuclear power, of course, will be an increasing percentage of the total. For those of you primarily in the financing of the electric industry, this chart is an index of how much new capital is going to have to be supplied to keep this industry going over the next 50 years.

Final Answers from Experience

Let me then summarize this picture. The industry itself, the AEC atomic energy groups, and the defense agencies are now in general agreement that atomic power is basically practical technically, that we are in a state of rapid flux in that there are various competing types of systems. The final answers, because there are good arguments on all sides, must come from actually building and testing some of these many types of plants in order to get the basic experience as to capital costs and operating costs, operating life, and all the factors that normally must enter into system expansion planning in terms of the future.

We are in a phase where almost everybody agrees that within the next five years we will see a fair number of test-type, fairly large-scale atomic power plants built or under way. The Atomic Energy Commission's own five-year reactor program represents one program, but if the industry is going to accept its proper responsibility in the atomic power field, progress can and should be much faster.

Progress, of course, must be pro-

(*Continued on page* 262)

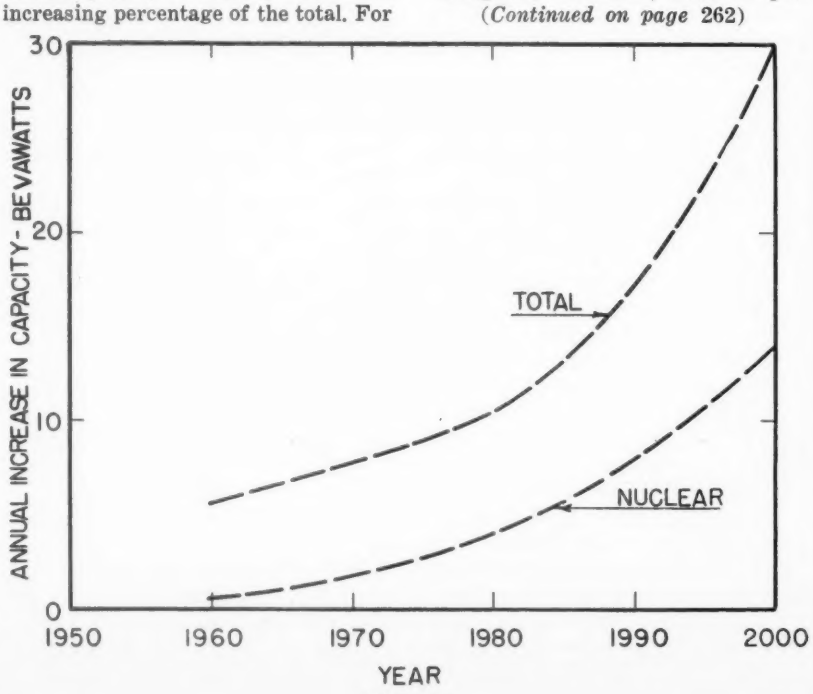


Figure 7

Report on Progress—Atomic Energy

Robert LeBaron

Assistant to the Secretary of Defense for Atomic Energy and
Chairman, Military Liaison Committee to the Atomic Energy Commission

An address before the 22nd Annual EEI Convention, Atlantic City, N. J., June 3, 1954

THE development of peacetime power and progress in the entire atomic field is of vital interest to our country. The time has now come when we can have more than one customer for the atom, though today the military is the primary customer.

There are people who say we cannot have atomic weapons and peacetime power at the same time. There are some people who believe that we do not have enough nuclear scientists. Everyone feels that we need more uranium.

But we are far enough along in our atomic program to develop weapons and peacetime power at the same time. Atomic weapons are a small operation after the uranium isotopes and plutonium are available. The production is essentially the same whether the uranium is made into weapons or is used in peacetime power.

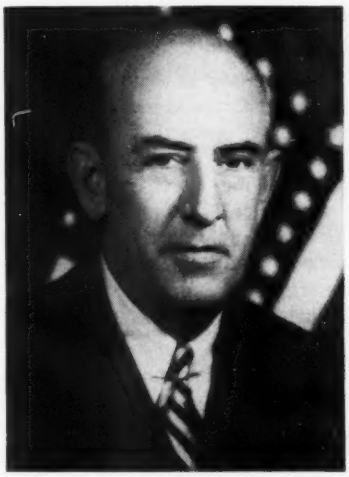
Continue Expansion at Top Priority

We have large production plants that will continue to expand. They are growing rapidly. Our military requirements for atomic weapons will also continue to expand. They, too, are growing rapidly. There is little hope of reaching a "saturation stockpile" in these uncertain times. Our only practical course is to continue the large expansion now under way at top priority.

Only a small amount of fissionable material is used in our power reactors. Our supply of atomic weapons is not compromised by the demands of these reactors. This fact was not true in the beginning. It is true today. The building of civilian atomic power plants will not impair the supply or production of atomic weapons. They are not rivals.

Fuel costs for atomic heat will steadily decrease. The cost of building new reactors will decrease. Both these activities can be carried on without interference with the weapons program.

As our stockpile of fissionable material grows, our reactor engineers have increased freedom of design. The atomic fuel that we use in these power plants does not have to be expensive. In our first reactor designs, it was necessary to use a sizeable amount of expensive fissionable material in order to develop the combustion of the cheaper garden-variety uranium. Now that we have learned more about the technology of reactors, we find ways in which we can use more of the cheaper material and less of the expensive material. Soon, we will reach a stage where the use of the expensive material is somewhat analogous to that of lighting a match to start a roaring wood fire.



ROBERT LEBARON

The Breeding Process

Our future hopes are stimulated by the very attractive possibility that the day will come when the atomic fire creates more expensive fuel than it burns of the inexpensive fuel. Thus we face the possibility of converting a cheap material into an expensive material and producing a large amount of useful heat in the process. Technically, we call this the "breeding" process.

There are important advantages in developing both the weapons and the power programs at the same time. We have gained important new striking power for our Navy submarines, and nuclear power is bringing important advances in merchant-ship propulsion.

Today, small nuclear power plants in remote military locations are economical where the transportation of coal or oil is difficult. In time of war these plants could continue to perform when transportation facilities for coal or oil are not available.

Atomic - powered airplanes will greatly extend our air supremacy. These developments may be some time off, but they are real and can emerge within the next decade or sooner. The implications of nuclear air power are many and far-reaching.

Stationary atomic power plants can speed up our government plans for decentralization of key industries—a must in our hydrogen age. Mobile military atomic power plants can provide simpler transportation and service of supply to land armies.

The Best Sales Prospect

The advantages to our country from all these operations will be substantial as they become available. In time of total war all of these activities will be vital. They are also weapons of war.

We are witnessing the birth of a new basic commodity industry. Its present customers are the military services. They use its output to fabricate weapons and to build nuclear propulsion systems for national defense. Among its customers are also hospitals and research laboratories. They use its by-products for medical and industrial research.

The electric power industry is naturally one of its best sales prospects. Who can see where this nuclear power future may go? Our standard of living is directly related to the consumption of electricity. As this new power source becomes available to serve the growing kilowatt needs of a power-hungry world, who can predict what the new labor-saving atomic machines

will do for the comfort and dignity of the people of the world.

These atomic weapons of peace will surely outstrip the atomic weapons of war—once our military atomic shield has provided adequate peace insurance in a troubled world.

One of the questions is how this atomic energy industry will grow. What will be its pattern of growth? What yardsticks are available to indicate where and how we may expect future developments? Gazing at our "crystal ball" helps us to orient our own thinking about the future. Out of this inductive reasoning we draw personal road maps indicating where key-break-throughs, which will guide us to the superhighways of the future, are likely to come.

A Blueprint of the Future

We know that we cannot predict the future—especially the atomic future. At the same time we must continue to draw these mental blueprints even if we destroy them a few weeks later in favor of new ones. We learn something in the process.

I would like to present such a blueprint here. The basic operation involved in this new field is the manufacture of neutrons. This basic operation is concerned with the development and processing of materials that can be used as a source of neutrons. It is also concerned with the development of new materials that can be converted into more valuable atomic materials through the process of neutron absorption.

The alchemist's dream of the Middle Ages in transmuting lead into gold is now on the verge of becoming an everyday reality. The modern version is the transmutation of garden-variety uranium to plutonium, an operation that makes the alchemist's gold look like small potatoes, even with our inflated 1954 dollars. All of the activities which are involved in this new field, in the last analysis, come back to the production and use of these tiny neutron particles.

Some of these new materials are known. Uranium and thorium are familiar to all who read about atomic energy. Zirconium, bismuth, hafnium, and boron are emerging in our atomic energy vocabularies. What these new nuclear requirements will do to the economics of many chemical elements may be interesting to speculate on. Up to now most of the elements with significant nuclear properties have been chemical curiosities in our scientific museums, and not articles of commerce.

How the Atomic Industry Will Differ

Clues on how this baby industry will be different from its contemporaries can be found in the unique properties of these neutron-source materials.

First, the atoms that package these neutrons provide a concentration of energy on a scale that is difficult to comprehend. We speak of 1 lb of uranium being worth roughly 3,000,000 lb of coal. This is true because the neutron unlocks the inside of the atom and produces enormous amounts of energy that are not available from the burning of carbon.

The chemists and physicists have a sound scientific explanation for this great energy difference. In their world of electron volts, chemical transformations measure only a few electron volts. The splitting of an atom registers millions of electron volts of energy. The layman may not comprehend this tremendous increase, but the scientists have already learned how to put it to work and to use it in our nuclear technology.

Second, new and complex industrial problems are created by the very existence of these neutrons. New kinds of health hazards must be guarded against, but we are making steady progress with the problem of radiation.

There is nothing unusual in the development of a new material that has health-hazard properties. Chemical manufacturers have long been familiar with such problems. In the early development of tetraethyl lead for improving gasoline there was great concern about its inherent dangers. One leading scientist at a great eastern university predicted "wholesale death" on Fifth Avenue in New York if leaded gasoline were used. Similar predictions have a familiar echo in the recent stories of radiation danger from our hydrogen-bomb tests in the Pacific.

The cost of a pound of neutrons is something to conjure with. We cannot put them into a package and ship them in the same way that we do a barrel of oil. Yet these neutrons are the cornerstones of the hydrogen age.

There are many major industries that are important to us in every-day life where we do not package the basic commodity. In our communication fields we now depend largely on radio waves. No one has yet been able to find a way of packaging this commodity. In the world of today we live with many gadgets that function through means we neither feel nor see.

It takes imagination to talk about neutron factories and electromagnetic wave factories. Of course, neither neutrons nor electromagnetic waves have any permanent existence in terms of time as we understand it. They are, however, very real in terms of scientific time. In future time, neutrons will appear in our industrial cost accounting just like their predecessors in the energy field.

How Much Is the Industry Worth?

What is this atomic industry worth today? Let's take a look at some of its component parts. First, the physical plants today are valued at approximately $5,000,000,000. In addition, there are some $6,000,000,000 invested in inventory and experience. This totals about $11,000,000,000 of taxpayers' money that has gone into atomic energy.

The total assets of the United States Steel Corp. are something less than $3,000,000,000. The total assets of the DuPont Co. are roughly $2,500,000,000. The atom is already in the supermarket stage before it has opened its doors to private customers.

When we turn to the raw-material situation on which this new industry is based, we are equally impressed. The estimated reserves of uranium ore are approximately 25 times the total heat value reserves of coal. In comparison with oil and natural gas, they are roughly 100 times this amount. We know that increasing amounts of these materials are available to us in the North and South American Continents.

The total capital investment in laboratory facilities is not far from $300,000,000. There are almost 15,000 trained American citizens who work in these laboratories. The total operating costs per year are approximately $250,000,000. This does not include the facilities for the development of atomic weapons.

When we compare these atomic laboratories with the facilities of pri-

vate industry, it is surprising to find that this total represents a greater effort than the combined industrial research efforts of the first four or five of the largest corporations in America.

When we think of the great diversification of interests of our private industrial corporations, and then compare the effort being directed solely toward the peaceful atom and its use, we get a practical idea of the enormous amount of money and effort that the government has already spent in connection with the development of the peacetime atom. It is impressive to realize that these facilities and trained personnel are a "going concern," adding to our store of knowledge.

Included in this research and development are the activities directed specifically toward the development of nuclear power. During the last five years some $250,000,000 of taxpayers' money has been expended in this field alone.

None of the above includes the weapons stockpile and its impressive relation to national strength. For security reasons this is included in the $6,000,000,000 investment in inventory and experience.

Political Considerations

The future of this new industry is bound up with political, military, and economic problems of international importance. There are people who say today that the hydrogen bombs have eliminated major wars as instruments of national policy. Military people recognize that tactical atomic weapons have far-reaching effects on the composition of future military forces. In the long run, this military trend will affect every home in the United States.

Adequate legislation is needed to promote the American climate of competition as the best way of increasing the value of the industry and bringing the most benefits to the largest number of people. This matter is now before the Congress.

In addition, there is a growing feeling that the peaceful atom holds the key to world survival. At a recent dedication of a new industrial laboratory in the Middle West, I proposed an immediate all-out national effort for the production of peacetime power. I based this proposal on the five-year reactor program of the Atomic Energy Commission, pointing out that an inspired peacetime effort, adequately supported, could compress the work of ten years into five. If it was important to build an atomic bomb in three years, when the ordinary course of effort could easily have required 25 years, is it not more important to build our peacetime power future in the shortest possible time?

If we could only organize this all-out national effort for the peaceful atom, we could save five years time. In the hydrogen age this saving of time may well save the nation.

Five Facts

I did not advocate a "crash" program that would waste taxpayers' money. I did emphasize that much more could be done and should be done on an all-out basis. We are no longer concerned with the "if" in peacetime power but only the when, where, and how. At a time when all the peoples of the world are grasping for any straw that promises peace, where is a better cause than a peacetime atomic future?

These facts stand out:

1. Atomic weapons and peacetime nuclear power are not rivals. Both can and should be developed now.
2. Our country already possesses a multi-billion dollar atomic inheritance in manufacturing facilities and trained personnel.
3. The future power potential of this new industry is enormous.
4. We must go forward. We must use the American pattern that has proven so successful in all our industry. Americans understand competition. We have never had any sympathy for monopoly — even government monopoly!
5. All-out atomic strength stems from one basic atomic activity —the production of these new neutron-source materials. As this industry grows and our basic atomic capacity grows larger, our reservoir of national strength for atomic weapons and peacetime nuclear power will both emerge from the same parent commodity.

The neutron source materials will take their place along with our other basic commodities. These old-fashioned commodities have made the United States the richest country in the world. Our world leadership in the difficult years ahead may well rest on these neutron-source materials.

It is of key importance that we understand the growth pattern of this new atomic industry. We can produce atomic weapons and civilian nuclear power at the same time if we determine that this must happen.

It is my conviction that atomic weapons and peacetime nuclear power are partners in our struggle for survival. Atomic bombs and peaceful atoms are not rivals. We need them both. We need them now. We can have them both—if our American system of free enterprise can be organized and stimulated to carry out the job. This must be done.

Fall Range Campaign

THE Fall, 1954, Co-ordinated Electric Cooking Jubilee, a "Special Jubilee Showing" of electric ranges, will be programmed nationally to give added customer impact to local range campaigns. H. H. Brenan, New Chairman of the EEI Residential Section, has announced that the industry-wide campaign, to be concentrated in September, October, and November, is being co-ordinated by the Residential Promotion Committee.

The record participation by investor-owned electric companies in the spring, 1954, campaign is expected to be topped in the coming promotion, Mr. Brenan said. Also, wide backing by manufacturers, dealers, and distributors is anticipated.

The campaign's plan of action outlines the need for wide display and media advertising, and for intensive use of booklets and folders. Special items prepared for the promotion include display advertising kits, a range sales folder, range-top sticker, and plastic aprons embossed with the campaign slogan, "Be Modern . . . Cook Electrically."

It was suggested that a consumer contest be run locally by electric companies. Contestants would be asked to finish the phrase, "I want to be modern and cook electrically because . . .," in 25 words or less.

It was also suggested that November be used to close prospects developed in September and October. This would permit a build-up to the highlight day of Light's Diamond Jubilee, October 24.

Nuclear Power and Utility Securities

Eldred H. Scott
Controller, The Detroit Edison Company

An address before the Seventh Annual Convention of the National Federation of Financial Analysts Societies, Chicago, Ill., May 16-20, 1954

THE privately owned electric industry has been one of the strongest unsubsidized growth industries in modern times. No clues have yet appeared in its growth curve to indicate a condition of approaching maturity. The characteristic of doubling the business every ten years has been the mainspring behind a creditable record of technological improvement. New equipment added to supply new demands provides the opportunity for the rapid introduction of such improvements.

This favorable performance record and the prospects for its continuance will be of uppermost importance when, as, and if nuclear power becomes economically available.

Of course, growth alone has not been the whole story of electric companies. The industry has been staffed by people ever alert to new ideas and methods. This is exemplified in their eager approach to the new resource of nuclear energy in a spirit of cooperation tempered with friendly rivalry. There has been heated debate over the relative promise of the various types of reactors. This is indeed a healthy situation.

Technological Improvements

In 1929 the electric industry celebrated the golden anniversary of one of the great technological developments of modern times, the invention of the first commercially practical incandescent lamp by Thomas Edison.

This year the Diamond Jubilee of this historic event is being celebrated. In the 25-year interval between celebrations there have been no spectacular developments in the industry equal in importance to Edison's inventions. There has been considerable progress, to be sure, but it has been at a decreasing rate. This is shown in the adjoining tabulation of power plant statistics, which facts have led to statements that conventional steam units are approaching the practical economic limits of efficiency.

The heavy capital investment and low annual turnover that are characteristic of electric companies, coupled with steady expansion, have made the availability of new capital of critical importance. The very steadiness of progress in technological developments has been a source of strength in obtaining capital on favorable terms.

Growth Has Tempered Obsolescence

The investor has had the assurance that his investment would not become wiped out overnight by obsolescence. He has been in the fortunate position of having the opportunity to increase his profitable holdings rapidly in a situation with which he is already familiar. The industry has never been faced with huge write-offs because of obsolescence. Growth has been so rapid that it has usually been necessary to retain considerable old equipment on the line or available for standby.

A recent study conducted by a large utility disclosed that during the past ten years only 2.5 per cent of its plant was retired because of obsolecence.

It should always be remembered that, unlike coal, gas, or petroleum, electricity is a form and not a source of energy. Nuclear power will merely provide a new form of fuel. The reactor can replace only the boiler portion of thermal generating stations. The turbo-generator, transmission, and distribution systems will still be necessary.

POWER PLANT COST REDUCTION PROGRESS

	1900	1929	Today's Construction
Conservation of Fuel—Pounds of Coal per Kwhr (Based on 11,700 Btu per lb)	5.20	1.20	.72
Conservation of Engineering Materials—(Pounds of Material per Kw of Generator Capability)	79	15	13
Steam Pressure—Psig	110	550	4500
Steam Temperature—Degrees F	350	700	1150
Larger Size Individual Units—Kw	50	50,000	260,000

In any new development, such as atomic energy, from time to time appraisals tend to get out of perspective. There are many advocates of the new approach but few evaluators. This is the easy path. Early we had the automobile running around the streets of London powered by an atomic power box the size of a thimble. The latest jarring note for utility securities was the "atomic" battery. Calmer appraisals show that the latter's ultimate capabilities for power production are practically nil.

Perhaps we should accept *Electrical World's* comment that the combination of a sufficient number of atomic batteries to operate a household refrigerator would cost about $20,000,000. Even if we assume that electricity from nuclear power will be generated at less cost than by the use of conventional fuels, we can be sure that the effect, if any, on the value of securities of electric companies will be constructive.

The composite balance sheet of the electric companies in the United States shows boiler plant equipment of $2,500,000,000. This represents only about 8 per cent of total assets. The fuel to run this boiler plant equipment amounts to about $1,000,000,000 a year or only 14 per cent out of total revenues.

Area of Cost Reduction Limited

It can be seen that the area of cost reduction is limited. Under the most ideal conditions that can be premised today, the elimination of all fuel cost defines the maximum limit of savings presently conceivable. If we disregard the seemingly certain higher fixed charges resulting from the use of radioactive nuclear power it would seem that the maximum area of cost reduction is about 14 per cent of revenues.

The impact of nuclear power on the domestic and small commercial classes can never be of much moment because so much of their costs are allocated to

transmission, distribution, and customer service expenses. Only about one-sixth of the average 3¢ per kilowatthour charge is for fuel.

The atomic furor and studies have been almost exclusively devoted to the plant of the future. Our investor friends are prudently more concerned over the plant in service today, which forms the security back of their present large holdings of electric company debt. The problem of investing or not investing in the nuclear plant of the future can be solved when, as, and if an offering of this type is ever made.

The consideration of past or "sunk" costs gives the investor added assurance that nuclear power will never be able to actually replace the conventional plant except as the existing plant wears out or maintenance and operating costs become prohibitive because of the age of the equipment. A change-over would only be feasible if the nonfixed or variable costs of the conventional fuel plant exceeded the total costs of the nuclear plant.

In an existing coal burning plant generating at 7 mills per kilowatthour, the expense may be split in the ratio of 3 mills for fixed charges and 4 mills for fuel and other variables. It will be profitable to convert to nuclear power only when the total cost of the new method is less than 4 mills. The 3-mill portion has already been incurred or "sunk" and can thus be disregarded in any replacement comparison.

Regulatory Safeguards

Three regulatory developments, one of which is of a historical nature and the other two more recent, are reassuring to the investor holding any doubts as to the effect upon the future value of his utility securities which might accrue from the adoption of atomic power.

Probably for the first time in its history, the National Association of Railway and Utility Commissioners has formed a committee whose sole purpose is to study and keep informed on a technological development, namely, nuclear power. This early action by such a body is a singular protection against anything perverse happening in this field to endanger utility securities.

In another constructive step our own state commission of Michigan has issued an order directing all research and development expenses of nuclear power by electric power companies to be charged to operating expenses. Thus, such expenses will be treated in the same manner as other traditional research and development expenses for both accounting and rate considerations. This is a very constructive step that is being followed by other state commissions.

Regulatory precedent in the gas (natural gas) and telephone field (automatic dialing) should allay any fears as to the ability of most electric companies to recover from customers any large write-offs of property occasioned by the introduction of nuclear power. Utilities could easily prove that their property losses were caused by unforeseen developments. If it were otherwise, progress would be stopped and expansion would be hindered.

In a situation where a gas plant was suddenly superseded by the adoption of a new process, the Supreme Court of the United States held that the lower court should have allowed in the rate base the unamortized cost of the superseded plant. (Pacific Gas and Electric v. San Francisco 265 U.S. 403.) Excerpts from the Supreme Court's opinion follow:

> . . . the demonstrated economies thereby effected are justly to be devoted to reimbursing the company for the loss of capital occasioned by the obsolescence, continuing each year until the loss is made good, with interest . . . progress in service is promoted by giving a gas company an incentive to improvement of its machinery and its processes in the shape of increased profits.

Utilization Bottlenecks

Sparked by atomic weapon headlines, the use of nuclear fuel for the generation of electricity has aroused man's imagination. He has ignored the fact that electricity is already about the cheapest thing in his family budget. In the Detroit area the median electric bill is about 1 per cent of disposable income—only half the prewar relationship. At the same time his use of electricity has more than doubled.

He little realizes that the area of competition between nuclear power and conventional fuels is a relatively minor area of his total delivered cost of electricity.

If we grant that nuclear power is a much cheaper fuel, there is still another hurdle to that "abundant life" that is to be found right on his own premises. This hurdle becomes increasingly important as man further insists on using much of his energy requirements in the form of the more convenient but thermally less efficient electricity as measured from mine to utilization device.

Even if electricity were to be given to the customer free of charge he would have a two-part problem of utilization.

Work and Heating Electricity

It is perhaps little realized that the nature of the utilization process in the home and factory makes it imperative to use work electricity in certain equipment, i.e., for lighting and motor driven appliances. In the process and comfort heating field where electricity faces stiffer competition, such as for heating water and air, the decision as to which form of energy will be utilized in the factory depends mainly on cost alone, whereas cleanliness, and many other factors in addition to cost, influence the home and small commercial business.

The average domestic customer presently uses 2,340 kwhr of electricity a year. The noncompetitive or work portion for lighting and motor appliances amounts to 1,400 kwhr, or 60 per cent of the total. The balance of 940 kwhr is used as heat energy for operating his range, water heater, etc. This is the area that is competitive with gas and oil.

In the all-electric home of tomorrow his total usage would be 24,000 kwhr. The work portion (lighting and motors) is 4,350 kwhr or twice the total average use today for all purposes. The portion used as electricity reconverted to heat energy is 19,650.

If the investor in electric company securities still has any doubts as to the future economic importance and value of his holdings, he can obtain solace from the foregoing figures. Today's customer, even if he had a reactor in his basement, would still have to generate electricity for 60 per cent of his present-day requirements, as the reactor alone would produce heat but not electricity. If he had an all-electric home, he would have to generate 4,350 kwhr for his motors and lighting or almost twice the average

home usage for his total requirements of 2,340 kwhr as of today.

A similar situation exists in industry where only 14 per cent of the total energy consumed is used for comfort and process heat.

Wiring and Appliance Bottlenecks

If we assume free electricity at the pole outside the door, the customer is still faced with the investment problems of utilization. He must have adequate wiring and the appliances to use the electricity properly.

Very few of the 40,000,000 homes in the United States are adequately wired to use large volumes of electricity. The electric industry is taking broad action to solve this utilization problem, but progress will be slow. It is estimated that the cost to adequately wire the average old home is about $450. The annual fixed charges on this amount, at 15 per cent, are $62 or just about equal to the average domestic bill for electricity today.

Based on today's saturations of domestic appliances, the average investment in appliances is $1,230. If everyone had all the appliances available, the investment per customer in appliances would be $3,700. The annual fixed charges at 15 per cent on these sums are $185 and $555 respectively. These calculations ignore electric house heating, which would involve additional investment.

The competition of these heavy fixed charges on his utilization equipment will tend to keep nuclear power from revolutionizing the use of electricity in the home.

Due partly to the impact of regulation of the electric power industry, the benefits to security holders from the strong growth trend have been moderate but steady. It is entirely possible that this picture could be changed if the suggestion made before the convention of utility commissioners, September 22, 1953, by W. L. Davidson, Director, Office of Industrial Development, AEC, were followed. After discussing the possibilities of government operation or a joint government-industry undertaking, he developed the following third possibility:

> . . . which envisages a nonutility-type venture financed entirely by private capital. I use the nonutility term here in a generic sense, rather than intending to specifically exclude utilities from participation. But since there is admittedly a substantial risk involved here, there must perforce be a greater opportunity for reward. If utilities are to participate, either the regulatory bodies will have to adopt less rigid boundaries as to what constitutes valid risk and return for utility activities or else a large number of utilities might combine their effort with the pro-rated costs not considered to be of such magnitude as to constitute an abnormal risk . . . If the power produced was distributed by a utility, the purchase price between the utility and the plant owner would become a matter of interest to the local utility commission and presumably would be set at a figure close to that paid for conventional power of equivalent firmness. If by-products of the reactor could be marketed advantageously, the return on this venture might be in excess of that normally permitted utility operations.

Following is a question and answer statement by one of the utility industrial teams made to the Joint Committee on Atomic Energy, July 1, 1953:

Page 169—Atomic Power Development and Private Enterprise . . .

> 8. Would you expect to make your real profit by sale of plutonium to the government?
>
> We would want the privilege of selling plutonium to other industrial-power producers utilizing a cheaper, nonbreeder reactor. We would expect the government to be a customer—not a contract customer but a customer who goes upon the open market and finds that it can buy plutonium at a price lower than government cost.

Does all this point up a situation whereby "other income" might be as important to electric companies as it is to Canadian Pacific Railway?

A New Twist

The only threat to the safety of outstanding public utility securities is government competition. We now have a new twist to the "preference clause." With the advent of nuclear power, it is the Federal government itself that is to receive the preference instead of the customers of lesser subdivisions of government that were favored in the development of the nation's hydro resources.

The benefits of nuclear power have been perhaps oversold to the American public. This tends to hurt the possibilities of a revision of the Atomic Energy Act favoring development by private enterprise. To date, the Congress has ignored its mandate:

Art. I, Section 8—Constitution of the United States:

> The congress shall have the power . . . To promote the progress of science and useful arts, by securing for *limited times* to authors and inventors the exclusive right to their respective writings and discoveries (emphasis added).

Little did the founding fathers realize that an "inventor" of a revolutionary idea could turn out to be the Federal government itself, even though the inspiration and development have been the work of private individuals and business. And little is it realized today that it is now 15 years since nuclear fission was discovered, ten years since the first large-scale, self-sustaining nuclear reactor was demonstrated at the University of Chicago, and five years since the AEC announced its first program of nuclear reactors aimed at power.

Protecting Government's Investment

If the United States is to have a dynamic technology for a well-balanced economy, sooner or later the production of electricity by fissionable material will have to be turned over to private enterprise on a licensing basis. A fair royalty would be the market value of using the patent, although some may want to collect billions spent by the Federal government for war purposes.

There has been much talk of protecting the government's investment in atomic energy. Following is a summary of that investment taken

U. S. GOVERNMENT'S INVESTMENT IN ATOMIC ENERGY PROGRAM FROM JUNE, 1940, THROUGH JUNE, 1953

Total Appropriated Funds (AEC and Manhattan Engineer District)	$12,116,039,357
Less: Cost of Operations and Inventories of raw source and fissionable materials and weapon parts and assemblies	4,410,019,825
AEC Equity at June 30, 1953	$ 7,706,019,532

from the AEC report, dated January, 1954.

While the Federal government was putting $7,700,000,000 into the atomic energy program, the privately owned utilities were investing a similar amount in facilities for generating and distributing electricity by conventional methods.

INCREASE IN PRIVATELY OWNED UTILITIES INVESTMENT, JANUARY 1, 1940, TO JANUARY 1, 1953 (FROM FPC REPORT)

Capitalization, January 1, 1953	$22,206,000,000
Capitalization, January 1, 1940	14,583,000,000
Invested by Privately Owned Utilities During Atomic Energy Development Period	$ 7,623,000,000

Because of a utility's obligation to serve all comers on demand, a lot of this added investment was not made for purely profit motives. None of it could be deferred to await a more favorable economic climate. Growth always has its economic penalty because the consumer's valuation of a commodity varies inversely with the quantity at his disposal. This economic law has had its effect on prices and profits.

Conclusion

The vast expansion in electric power facilities required to meet ever expanding demands has employed all generating facilities available. As previously stated, there has been very little opportunity to retire any older equipment. The magnitude of this increased investment clearly indicates that there would be every opportunity to introduce nuclear power facilities in an orderly manner and that forced obsolescence could hardly become a major factor.

The private-enterprise investment in utility plant is part of the secondary wealth of the nation. It is subject to seizure by our Federal government in time of war. It serves about 80 per cent of all the people in the country. Ownership is shared by a majority of its citizens through investment backing their insurance policies and their own personal investments. The utilities have done an outstanding job of serving the public in war and peace.

During the period in which the Federal government was accumulating its equity of $7,700,000,000 in the atomic energy program, the privately owned utilities paid $6,000,000,000 to the Federal government in taxes. This fact should at least give them some sort of priority over the nontaxpaying public agencies that are actively opposing private-enterprise participation in atomic power.

The above parallel pointing up the advantages of the free-enterprise system recalls to mind the fact that here in this country we have enjoyed a guns and butter economy during these troublesome times. In other countries operating with different economic systems these same atomic facilities will also be constructed. The difference comes in the fact that the consumer economy suffers and in some countries is nonexistent. In lieu of taxes from the free-enterprise economy, other governments will achieve the same result at the expense of consumer production.

The privately owned public utility industry has demonstrated its record of service and stability. It has the capacity and will to expand. Subject to security protection, surely a benevolent government, following its policy in other fields, can entrust this same private industry with the information it has developed on atomic power. Its patents in this field can be offered at a price based on the value to the participating company and to the general public that it serves.

U. S. Census Survey Reveals Important Data on Average Size of Households and Families

DURING the years between March, 1950, and April, 1953, the number of households in the United States increased about 3,000,000, according to the results of a sample survey announced recently by the Bureau of the Census. This growth is largely attributed to a substantial increase in the number of households maintained by older persons with no relatives sharing the home.

The average size of a household in 1953 was 3.28 persons, as compared with 3.35 persons in 1950 and 3.67 persons in 1940. The decline in members per household has occurred mainly among adults. Between 1940 and 1953, the average number of children under 18 years of age decreased only moderately, from 1.14 to 1.09 or 4 per cent, whereas the average number 18 years of age and older dropped more sharply, from 2.53 to 2.19, or 13 per cent.

What the Changes Reflect

According to the survey, these changes in household size reflect a number of developments, among which are the following:

1. The high marriage rate and the decline in age at marriage, which have reduced the proportion of young adults living in their parent's homes and increased the proportion of new households with a small number of adults;
2. A reduction in the proportion of married couples without their own households;
3. An increase in small households of older persons whose children have left home; and
4. The high birth rates since 1940, which have increased the average number of children in the younger ages under 18, while the average number of children in the older ages under 18 has declined.

Family Size

The average size of family was 3.53 persons in 1953. (This figure is above the average size of a household partly because some households consist of only one person, whereas families must comprise at least two mutually related persons, by definition.) The average number of (related) children under 18 years of age per family was 1.24. In nearly half of the families, however, there had not yet been any children, or all children formerly in the family had left home or died. If the analysis is limited to families with one or more children still living in the home, the average number under 18 years of age was much larger, 2.17 children.

Between 1951 and 1953, there have been, on the average, about 450,000 married women whose husbands were away from home in the armed forces. Close to 40 per cent of these wives

HOUSEHOLDS, FAMILIES, SUB-FAMILIES, AND UNRELATED INDIVIDUALS, FOR THE U. S. —1930 TO 1953—(IN THOUSANDS)

Type of Unit	April 1953	April 1952*	April 1951*	March 1950*	Increase 1950-1953 No.	Increase 1950-1953 Pct.	April 1940	April 1930
Household	46,828	45,872	44,935	43,822	3,006	6.9	34,949	29,905
Primary Families	40,680	40,337	39,599	38,961	1,719	4.4	31,491	27,547
Husband-Wife	35,560	35,138	34,378	34,075	1,485	4.4	26,571	23,649
Other	5,120	5,199	5,221	4,886	234	4.8	4,920	3,898
Primary Individuals	6,148	5,535	5,336	4,861	1,287	26.5	3,458	2,357
Families	41,020	40,708	40,041	39,426	1,594	4.0	32,166	27,980
Sub-Families	1,962	2,055	2,224	2,397	-435	-18.1	2,062	1,615
Married Couples	37,106	36,696	36,136	36,091	1,015	2.8	28,517	25,174
With Own Household	35,560	35,138	34,378	34,075	1,485	4.4	26,571	23,649
Without Own H'sehold	1,546	1,558	1,758	2,016	-470	-23.3	1,946	1,525
Unrelated Individuals	10,026	9,370	9,544	9,166	860	9.4	9,277	8,658

NOTE: *Revised: Current Population Reports, Series P-20, No. 53, April 11, 1954.

have maintained their own households, and 60 per cent have shared the living quarters of others. Nearly all of those who kept up households of their own had young children, whereas only a minority of the remainder had children. About nine out of every ten who shared living quarters of others were staying with relatives. Among one-fourth of the married couples, both the husband and wife were members of the labor force in April, 1953. This proportion has increased somewhat since 1950 when it was about one-fifth.

The growth in number of new households in the United States during the past few years has been great. However, the number of residential and rural electric customers has grown even more than households. This is shown by the following table. The major portion of the increased number of electric customers each year has been the result of new home construction. But it would appear that the larger increases in electric customers as compared with households has to a great extent come from the connection of previously unserved homes and farms to utility lines. This conclusion would seem to be substantiated by the fact that the annual difference between the increase in households and the increase in number of residential and rural electric customers has narrowed as we approach saturation for domestic electric service throughout the country.

	Number of Households		No. of Residential and Rural Electric Customers	
	Total	Annual Increase	Total	Annual Increase
March15, 1950	43,822,000		37,494,250	
April 15, 1951	44,935,000	1,113,000	39,568,927	2,074,677
April 15, 1952	45,872,000	937,000	41,249,904	1,680,977
April 15, 1953	46.828,000	956,000	42,605,759	1,355,855

Safety Merit Award Certificates Presented to Nine Companies Between February 15 and June 1

THE following awards of Safety Merit Award Certificates were made in the period between February 15 and June 1:

Alabama Power Co.
Electric Operations..... 1,425,011
Production Department.... 1,001,342
Central Power and Light Co.
Entire Company..... 1,604,703
The Cincinnati Gas & Electric Co.
Electric Operating Department 1,000,000
Consolidated Gas Electric Light and Power Co. of Baltimore
Electric Division..... 3,120,724
Meter and Installation Department 2,004,043
Dallas Power & Light Co.
Entire Company 1,126,555
Monongahela Power Co.
Entire Company 1,328,136
Southwestern Public Service Co.
Entire Company 1,000,000
Texas Electric Service Co.
Wichita Falls Transmission Division 1,105,402
Wisconsin Power and Light Co.
Beloit District 1,006,904

The 2,000,000-man-hour certificate awarded the Meter and Installation Department of Consolidated of Baltimore recognized an accident-free period commencing July 28, 1949, and expiring April 27, 1954. At the date of application, there were 193 employees in this department. The first 1,000,000 man-hours were achieved on October 31, 1951, and the record continued unbroken until last April.

Consolidated of Baltimore's Electric Division, employing over 5000 people, continued its accident-free record to achieve a 3,000,000-man-hour award. Certificates for 1,000,000, 2,000,000, and 3,000,000 man-hours were applied for and issued between February 15 and June 1.

Early Sales History of Industry Recorded

"SELLING Electric Service, 1879-1954," an unusually interesting and informative account of a very important phase of electric industry progress, has just been published as a contribution to Light's Diamond Jubilee celebration.

Written by William E. Clement of New Orleans Public Service Inc., the 72-page, illustrated brochure is largely concerned with the inspiring story of the sales and business-development problems that faced the electrical industry during its early years.

Reminiscences of the early days and accounts from the author's over 50-year-old scrapbook have been combined to give a "specialized record of strenuous and oftentimes grueling sales work, directed toward a goal about which none of us knew too much, a story that carries general interest and should not be lost to posterity."

Orders for quantities should be addressed to the Electrical Association of New Orleans, Inc., 921 Union Street, New Orleans 13, La. Prices are as follows:

1 to 24 copies ...$1.00 each
25 to 99 copies ...$ .85 each
100 to 299 copies ...$ .75 each
300 or more copies..$ .70 each

Customer Relations

Henry B. Sargent
President, Arizona Public Service Company

An address before the 22nd Annual EEI Convention, Atlantic City, N. J., June 2, 1954

CUSTOMER relations, which are of primary concern to all of us in our industry, are either good or bad. There is no middle ground. Mediocre customer relations are unsatisfactory and may become bad almost overnight if it becomes necessary to increase rates or seek a new franchise.

In my mind, we have good customer relations when our customers have a feeling of friendship toward us, when they like us, understand us, and will respond to the things we want them to respond to. Bad customer relations, on the other hand, are reflected by ill will, dislike, antagonism, and conflict.

You may wonder why Fig. 1 is a picture of Reddy Kilowatt. There are two reasons. First, no symbol in our industry is known by more people than Reddy Kilowatt. Second, 250 of the operating companies in the United States subscribe to the service of Reddy Kilowatt. I feel that if companies subscribed equally well to the other programs of our industry, perhaps it wouldn't be necessary to do so much talking about customer relations.

The first ingredient of the type of public relations program I think our industry must have is a sound philosophy. We must set a good example in our conduct and our fundamental beliefs so our customers are convinced that our interests are their interests,

HENRY B. SARGENT

and that we are vitally concerned with their welfare and the welfare of the nation. Otherwise, we are not going to have sound customer relations.

In this connection, we first must have a willingness to finance new facilities. One of the best examples of this is the proposal of five private utility companies to develop the electric power potential of the Niagara River. They have said to the Federal government and the Congress:

"Let us spend our money and build the facility at Niagara instead of taking the taxpayers' money and building it either by the State of New York or by the Federal Government."

Another example of willingness to finance new facilities is the Cabinet Gorge plant of The Washington Water Power Co. The Federal government estimated it would cost $75,000,000 and take four years to build a hydro plant at Cabinet Gorge on the Snake River in Idaho. Washington Water Power got permission to build it and completed the job in 20 months at a cost of $42,000,000.

We do have to be willing to spend risk capital to build new facilities such as these. They're just examples of the billions of dollars that are being invested each year in new plants and equipment.

We also should take a strong stand in favor of sound regulation for our entire industry, and Fig. 2 illustrates how unsound present regulation is, because only a portion of the industry is regulated. In this figure we picture the Federal government as having no regulation because I consider self-regulation as no regulation at all.

I got a feeling of some accomplishment recently when the House of Representatives Committee of the Interior announced that it would make no more appropriations for Federal expendi-

Figure 1

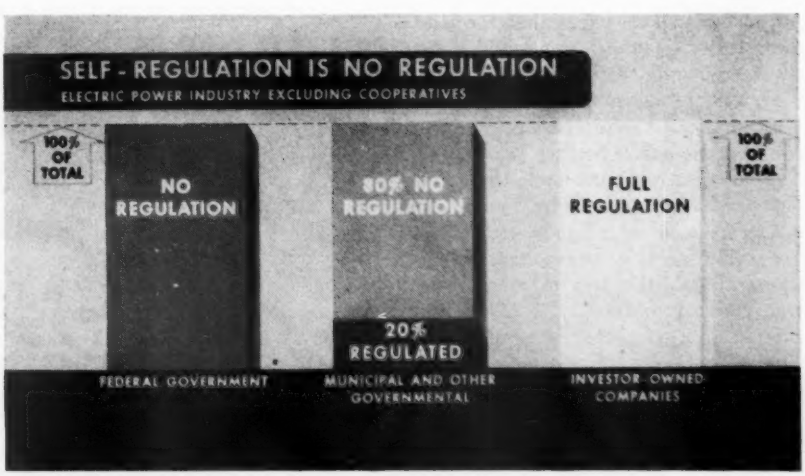


Figure 2

tures until such time as the Department of the Interior submits its rate schedule to the Federal Power Commission for approval. There are a number of instances in which the department has refused to do this. I think we can safely assume that at present the Federal government doesn't have any regulation as we in the private utility business know it.

Of the municipal and other governmental bodies, only about 20 per cent have regulation. I consider the other 80 per cent to be nonregulated.

Our investor-owned companies, on the other hand, are completely regulated. In this connection, we should remember that the group representing full regulation serves about 80 per cent of the customers in the United States.

The inequity of present regulation is further demonstrated in Fig. 3, which deals with taxation and shows the amount of tax subsidies given to Federal and governmental operations. You will notice that the Federal government pays about 2.4 cents in lieu of taxes out of each revenue dollar on its utility operations, while municipally owned operations pay about 2.6 cents. However, investor-owned companies pay 22.4 cents for Federal, state, and local taxes.

Thus, 80 per cent of the electric customers in the United States are discriminated against by having their tax money spent for the construction of facilities that are given tax subsidies.

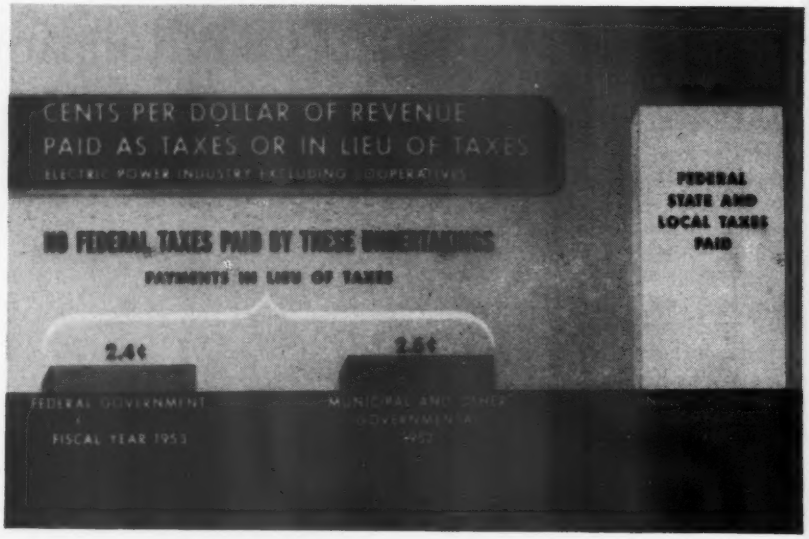


Figure 3

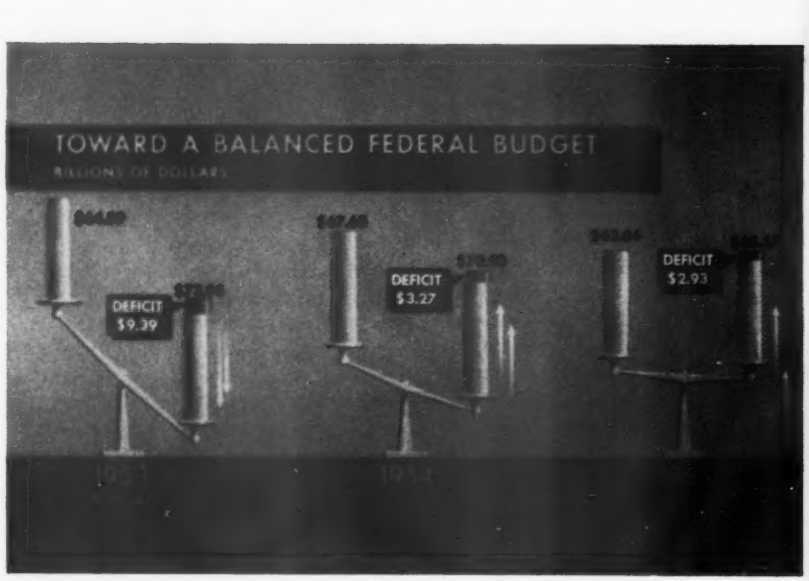


Figure 4

Sound National Money Program

Support of a sound national money program and a balanced budget is also an essential part of a sound philosophy. I think we will all agree that the Administration has taken some solid steps toward reducing the deficit in the hope of arriving at a balanced budget, which is certainly in the interest of the nation and the customers we serve. The progress that has been made toward a balanced budget is reflected by Fig. 4.

We may view with some satisfaction the new Federal power policy, which represents a little improvement over what it used to be. But I think the policy as it exists today is still far from acceptable. We cannot support any Federal power policy that discriminates — as the present one does — against 80 per cent of the customers in the sale of Federal power! Of course, we can never be reconciled with

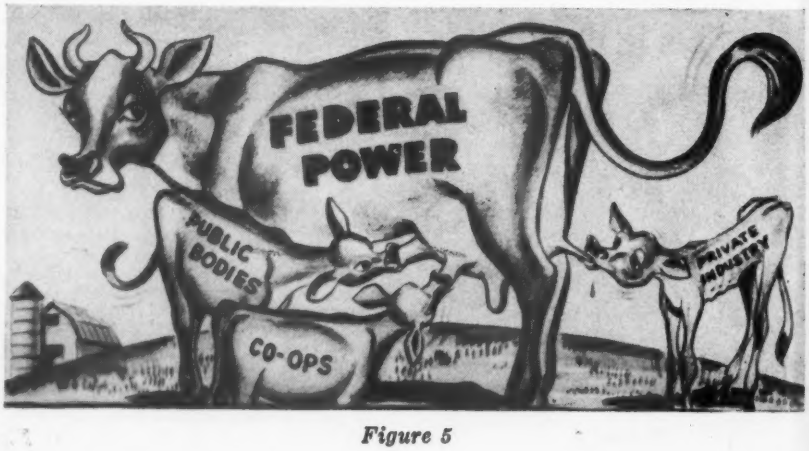


Figure 5

it until this unjust discrimination is removed. The only way to improve the policy is to see that new legislation is passed.

The accompanying cartoon, Fig. 5, pretty well tells our plight in regard to Federal power distribution. Remember that the calf on the right represents 80 per cent of the electric industry customers in the United States. And if there weren't two other fat ones in the picture, he wouldn't even be where he is. He would be pushed entirely away. I firmly believe that it is in the interest of our customers to do everything within our ability to remove such unjust discrimination.

In composing a sound philosophy, we ought to do everything we can to promote research. Fig. 6 portrays the increased interest and action privately owned utilities are taking in modern research. Over 55 companies today are spending millions of dollars on the development of atomic energy, and certainly they should be proud of the commendable projects in which they are engaged.

In connection with our research program, there are many other things that deserve consideration, such as the examples in Fig. 7. I think our industry ought to become more active in exploring ways to improve load factors of our systems so that the cost of our product may be reduced appreciably. Steps should be taken to investigate the possibilities of solar energy and determine the most effective ways this energy source may be used for the good of mankind.

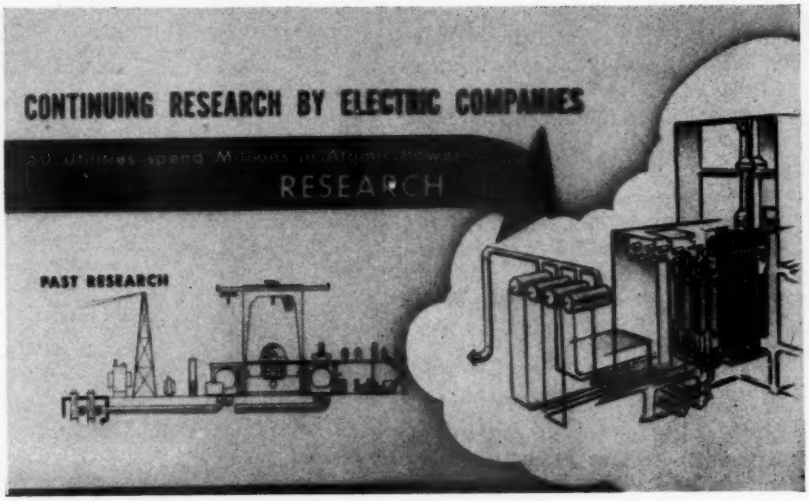


Figure 6

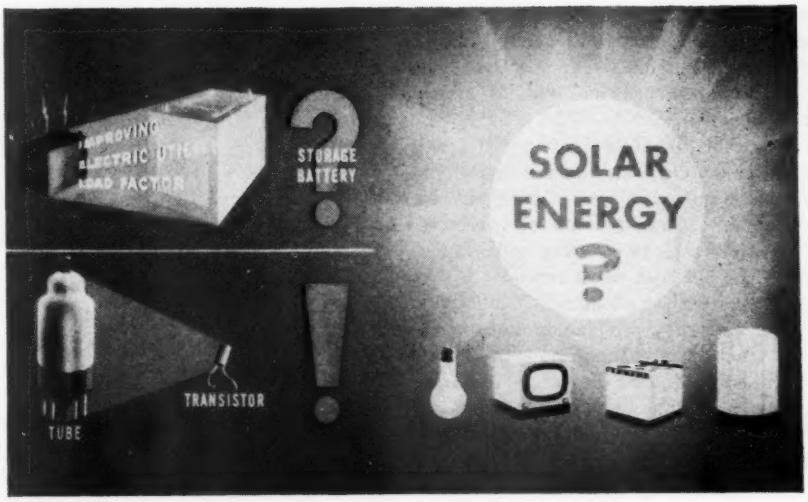


Figure 7

Efficient Operation

A second factor necessary as part of the customer relations program we must have is efficient operation. Keep in mind that any business enterprise operating under the rules and practices of the United States, and financed by private capital, must make a profit if it is to survive. And if the business is to make a profit, it must continuously introduce a better product at less cost.

Fig. 8 illustrates the kind of job our industry has been doing in this respect. The price of electricity since 1940 has gone down 26 per cent—in spite of the increased costs of the physical facilities that produce our product. During this same period, the price of bread has gone up 108 per cent; pork chops have doubled in price.

Also essential to efficient operation

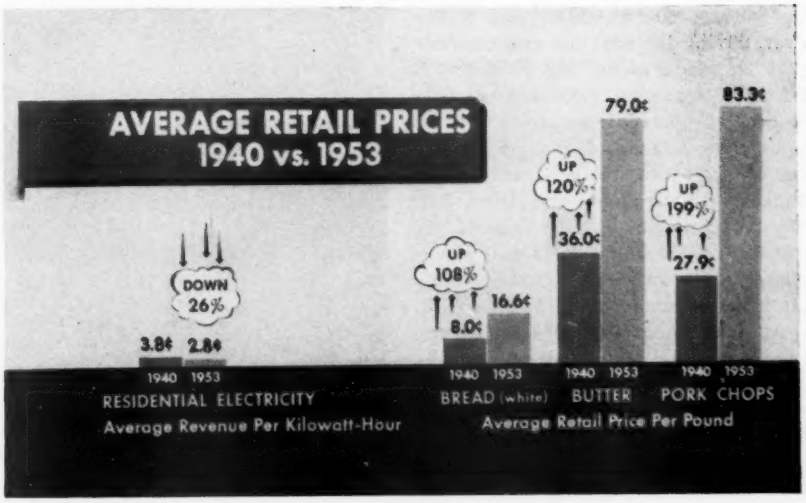


Figure 8

is a cost-conscious operating program. Fig. 9 shows the remarkable strides that have taken place in improving the efficiency of our plants. We soon expect to be able to produce a kilowatt-hour of electricity with about 8500 Btu of heat.

We have also raised the voltages on our transmission lines, and Fig. 10 points out that future research is aimed at a carrying capacity of 500,000 v. All of these things will enable us to make a better product at less cost.

An Adequate Construction Program

Of course, an adequate construction program is necessary for us to build these facilities. Typical examples of our industry's modern construction projects include the Sunbury plant of Pennsylvania Power & Light Co. and the Murray Gill plant near Wichita, an outdoor plant that helps Kansas Gas and Electric Co. carry a load that has increased three and one-half times since the war.

Another example is the construction of modern, functional substations such as one built by our company in Arizona. It was erected at less cost and offers a more pleasing appearance than the old open-work type.

Along with an efficient, cost-conscious operating program and adequate construction, we must have a sound cash program. Our companies must be operated so that we are able to maintain our high principles and financial integrity.

The vital importance of our financial integrity is clearly shown by Fig. 11, which lists our expenditures as an industry in 1946 at $650,000,000 and in 1953 at almost $3,000,000,000. Moreover, during the next ten years we expect to spend about $32,000,000,000. Of this, around $12,000,000,000 will be created from internal sources. The remaining balance of about $20,000,000,000 will have to be secured from banking, insurance, and investor groups. This can only be done if we price our product properly and if we maintain the financial soundness and integrity of our companies.

Another essential to efficient operation is a sound, hard-hitting, aggressive sales program. We must take full advantage of every available mass media to sell groups . . . such as demonstrations conducted by home service departments before large audiences. But we should never forget our in-

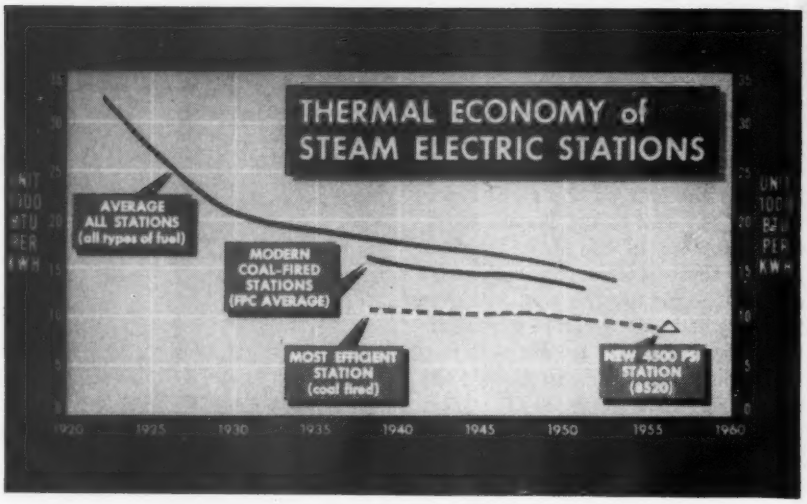


Figure 9

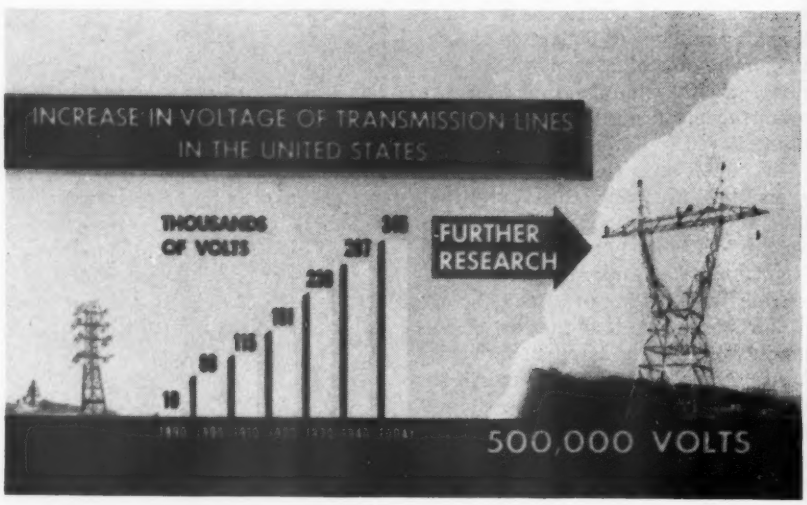


Figure 10

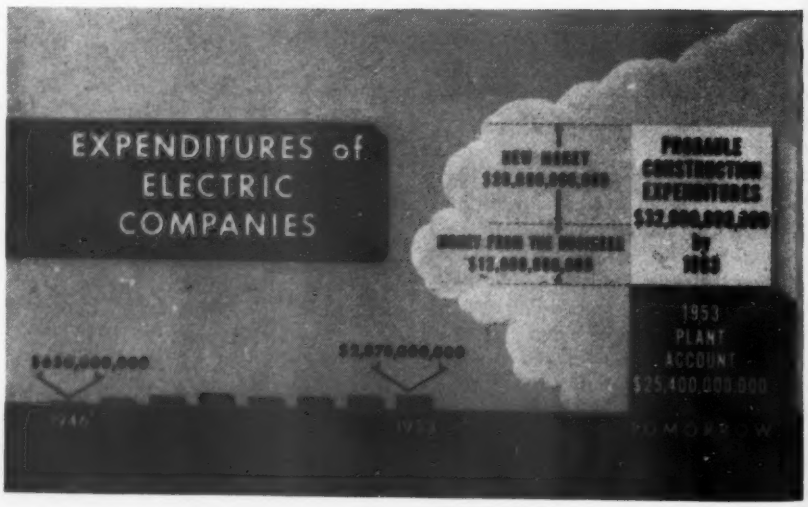


Figure 11

dividual contact programs—door to door selling—which nothing can replace under certain conditions.

In any aggressive, hard-hitting sales program, we must also keep in mind the interest of the large commercial customers who use our product. Every effort should be made to help them make the most effective and best use of our service, whether that means a reduction in power costs or not, because it is to our interest to keep those customers in business and help them prosper.

Building A Sound Organization

The fifth and final ingredient of efficient operation is an organization that accomplishes the objectives shown in Fig. 12. It doesn't matter if you have an efficient operating program, or an adequate construction program, or a hard-hitting sales program and sound cash program . . . unless you have the qualified people to carry them out. Without a sound organization, the rest of your efforts will be for naught.

In my opinion, there are five basic fundamentals to follow in developing a sound organization: objectives must be planned, activities organized, the right people selected for the jobs to be done, and performance must be coordinated to control operations.

Building an organization can be compared to building an automobile. First, the vehicle must be designed, which represents planning of objectives and grouping activities. Then, the automobile must be built, which corresponds to selecting and training employees. Along with this, top executives must be willing to delegate responsibilities to the people who work for them, and give them the authority to carry out those responsibilities so they can relieve the chief executive of handling details. A capable organization will never be developed unless authority is delegated.

After the automobile is built, it must be driven—which is parallel to co-ordinating the performance of all the people working in the organization. And in driving any long distance a road map is necessary, just as clearly outlined objectives and ways of reaching them are essential to a sound organization. Without a map, one is apt to be like the fellow who started out from Philadelphia bound for Atlantic City and wound up in Pittsburgh.

An informed public represents the third phase of our customer relations. Nothing can be accomplished by the programs we have listed if the customers we serve are unaware of what we are doing.

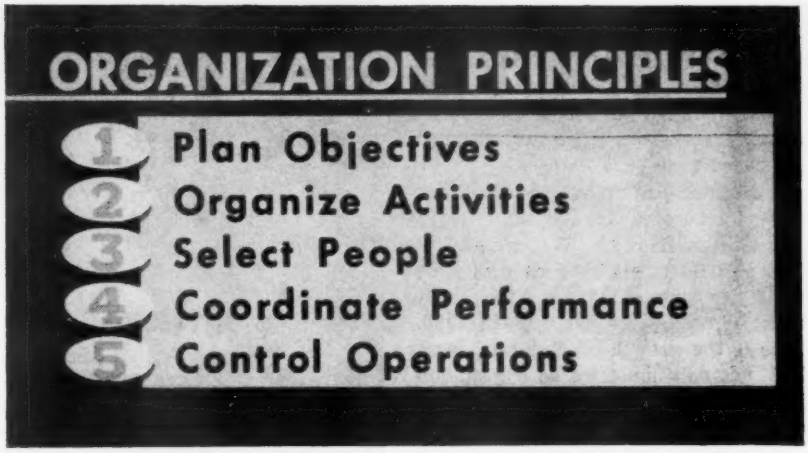


Figure 12

Telling Our Story

Fig. 13 shows us what happened when our industry was doing a good job but didn't inform the public. Reviewing the 30-year period from 1902 to 1932, we see that we brought service to almost 19,000,000 new residential customers. During the same time, we decreased the cost of our electric service from over 16 cents to less than 6 cents per kilowatthour. This was a remarkable achievement by any standard.

Then what happened to our industry? Fig. 14 provides the answer in terms of what occurred in the field of municipal ownership from 1933 to 1952. After more than 30 years of amazing performance, 70 per cent of the people who went to the polls to decide utility management in 1933 voted in favor of municipal ownership against private enterprise.

Then our industry began to get a little excited, and we got excited to the point where we started doing a good job at home in our own territories. The result was a startling decline of those favoring municipal ownership—a drop to only 2 per cent in 1952. Out of 111 elections that took place in 1933, 70 per cent of the voters favored municipal operation; last year, in 1953, not one of the 23 elections which took place resulted in a favorable vote for municipal ownership. That indicates clearly that when we do a good job in our home territory, we can whip municipal ownership.

But what's happened nationally where we haven't done the job that was accomplished locally? We didn't advertise, and we didn't let the public

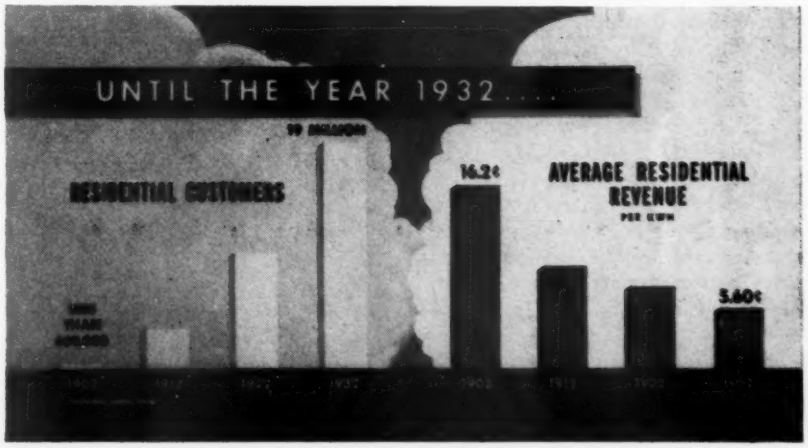


Figure 13

know our story as a national group. Companies having the same common interest, whether they were in Arizona or Arkansas, or Michigan or New England, failed to tell the industry's story to the public. And, what happened to us?

Two-thirds of 1 per cent of the power generated in the nation was Federal power as of 1932. Fig. 15 illustrates how this percentage leaped to 12 per cent in 1953, and we expect it to be around 15 per cent in 1956. This is the growth of Federal power. Yes, not only must we do a good job in our own territory; we have to put our shoulders to the wheel and do just as good a job nationally.

Working with Industry Organizations

How can we meet this national problem? One of the most effective ways is to join with other utility industry organizations and work together toward our common objectives. Among these is the Edison Electric Institute.

Ironically, 180 companies are participating in the Light's Diamond Jubilee observance this year, but only 175 of these subscribe to the sponsoring Edison Electric Institute.

We can correct our national problem by joining such groups as EEI and the Electric Companies Advertising Program (ECAP), which came into existence in 1941 and now has 138 members. Only recently has the industry, through ECAP, gotten the courage to run a forceful ad like the one on Hell's Canyon, where the facts are laid squarely on the line about the $357,000,000 in taxes that might have been spent on Federal development of this project. The extraordinary ECAP advertisement portraying a small boy and his inheritance symbolized by a Bible, door key, pencil, and a free ballot has been reproduced by the millions and sent all over the country. It has achieved unmeasurable good, won thousands of new friends for our industry. In view of its accomplishments and its potential as a means of bringing about better understanding on a national level, ECAP surely deserves better support from the members of our industry than it now receives.

The National Association of Electric Companies (NAEC), formed in 1945 and now supported by 100 members, is doing a grand job in Washington. This organization has taken

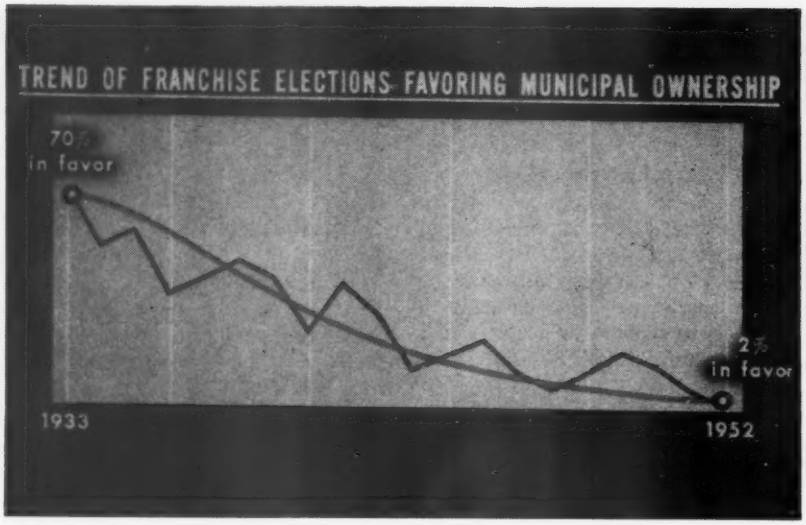


Figure 14

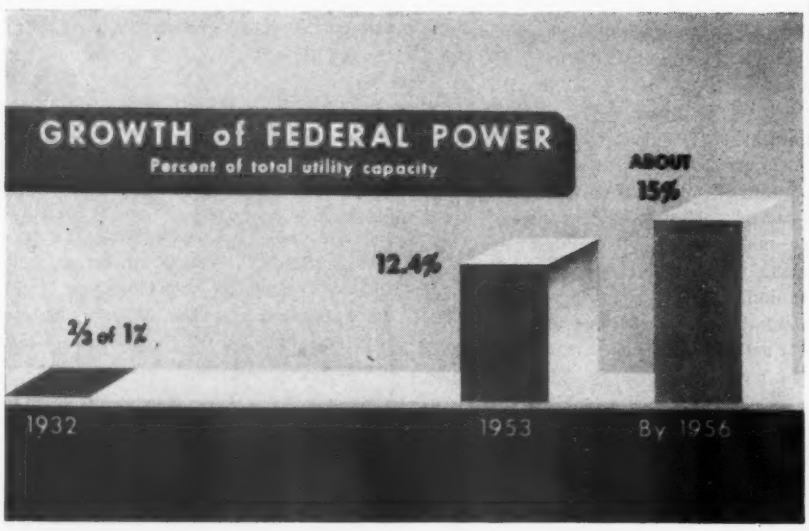


Figure 15

Figure 16

off the gloves and gone to bat for abolition of the preference system in a big way. The NAEC booklet, "Some Timely Talks About the 'Preference' System," should receive widest possible distribution among industry employees.

The most recent organization in our industry is the Electric Companies Public Information Program (PIP), which came into being in 1949. This organization prepares and distributes a wide variety of pamphlets and bulletins geared to keeping its members, employees in the industry, and our customers informed of private utility problems and progress. It should be accepted as an integral part of our nation-wide public relations program. Yet, only 76 companies from our entire industry are members.

I emphasize that all these national groups deserve much greater support than they receive from our industry today.

In order to better inform the public, we should also work with other groups outside our industry who have a common interest. As the cartoon (Fig. 16) illustrates, we should endeavor to combine our efforts with the railroad people, farmers, doctors, lawyers, and many others who have the same basic interest in the preservation of the private enterprise system. When we tell them our story and ask for help, they will be glad to join us. They recognize the threat of creeping socialism and know that some day they are going to need help, too.

Faith

The fourth essential to a sound customer relations program is faith. We may have a sound philosophy, an efficient operation, and an informed public, but we must operate on faith.

First, we need faith in our government. Regardless of whether we approve of the Indochina strategy, regardless of where we stand on the McCarthy issue and how investigations are conducted, when you get right down to the final analysis, there is no country in the world that offers its citizens the opportunities, the responsibilities, and the freedom that the United States of America offer.

A long time ago, George Washington said, "You can't have any government without morality; you can't have any morality without religion; you can't have any religion without God." We must have faith in this nation

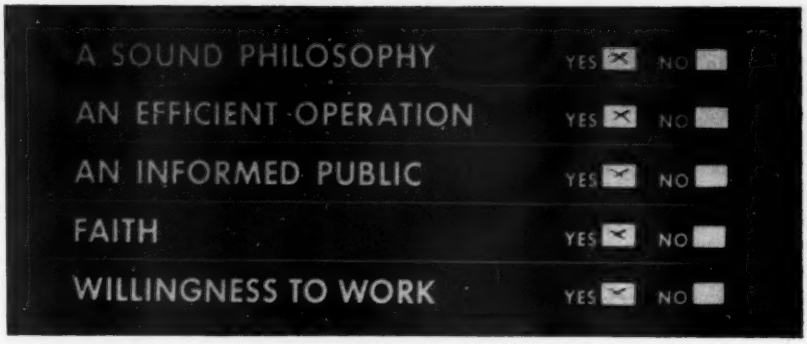


Figure 17

where we live—faith that we are going to solve these problems I have been discussing. They are problems common not only to our individual members of the utility industry but to the entire nation and to all business.

Next, we must have faith in our own business. Our industry hasn't even scratched the surface of what it will be able to do in the next 25 years. The outlook for our industry merits abounding faith and confidence in the future. We must make the most of the opportunities ahead and meet squarely the challenges we face. If we can tell this story of opportunity to young people, our difficulties will be solved when it comes to securing young engineers and college graduates to work for us.

Last, we need to have faith in the individual . . . faith in ourselves. This nation was built on the rights of the individual, and I cannot help but resent seeing and hearing the philosophy preached that we should take away from the haves and give to the have nots . . . take from those able to pay and give to those less able to pay.

This is a socialist theory. It is a theory that sounds very much akin to the Christian principle of sharing one another's burdens. But there is a vital difference.

When you take from those in accordance with their ability to pay and give to those in accordance with their needs, it is done by coercion. It is done by the Federal government taking away from you by taxation, without your having any voice in the matter. It's robbing Peter to pay Paul—legalized robbery.

On the other hand, the Christian principle of sharing one another's burdens is the proper way, for this is something done voluntarily. It is done because the individual has within his heart and within his soul a desire and willingness to assume responsibility—because he wants to do the things that are necessary to take care of his neighbor and make a good government—because he's willing to work for sound progress, freedom and liberty. So, we must have faith in the individual.

Willingness to Work

Last, but not least, in a good customer relations program, we must have a willingness to work. With all

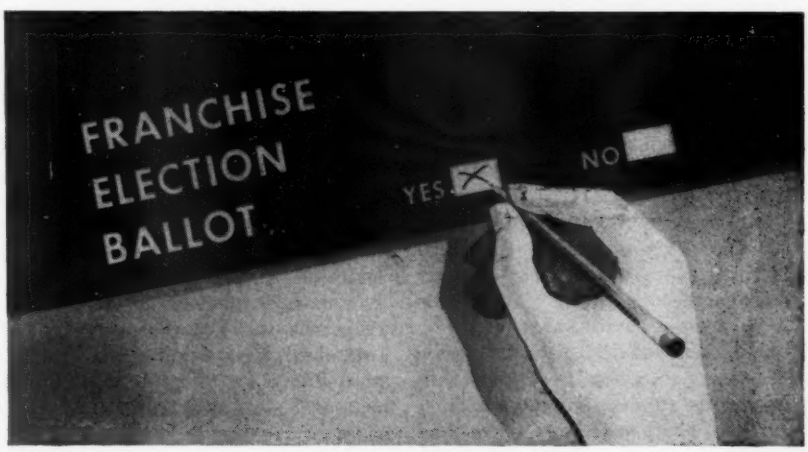


Figure 18

these other qualifications, we still must have a desire within ourselves to put more into the job than we get out of it—to give an honest day's work for an honest day's pay. This is true, whether it concerns a clerk working in an office or a lineman up on a pole.

I think as time goes on we will find more and more people who will cease wanting handouts and so-called creature comforts. They will be restored to the things of the spirit, the things of the mind, the things of the heart—to a point where they'll be willing to do those things necessary to preserve for them and for their nation all that has made our country great.

So, we end up with a sound customer relations program as represented by Fig. 17. I believe that in order to get the friendship, the support, and favorable response of our customers, we must have sound philosophy, efficient operation, and a better product at low cost. We must help to inform the public about the important issues that confront us all, let the people know where we stand as an industry. We must have faith in our country, our industry and ourselves as individuals. We must be willing to work and be proud of the contributions we make to our companies.

When the time comes for someone to put an X on a franchise ballot to express his opinion, he is going to put it on the side that we have convinced him is best for the nation and best for the customer. If we have done our job, he will mark it like the voter is doing in Fig. 18. And then when the customer sees Reddy Kilowatt, he will feel a warm friendship toward him because we will have built and earned foundations of friendship that will bring good customer relations to all of us.

Prospects for Use of Atomic Energy

(*Continued from page* 246)

jected on the assumption that the revised Atomic Energy Act will be passed in the present session of Congress or perhaps the next session. As recommended by the Atomic Energy Commission, by the Joint Committee of the Congress, and by the various industry representatives that have participated, the proposed revision opens the door to private industry on a fairly reasonable basis — perhaps not as good as many of us would like but a tremendous step forward from the obsolete Atomic Energy Act of 1946.

Seeing the Program Through

If Congress goes through with the new act, as we have good reason to hope, then the ball will be placed squarely in the hands of you as an industry. It is clear that the weapons program and a great civilian atomic energy program go hand in hand and, in fact, supplement each other in the national interest.

It is going to take a good deal of courage and a good deal of enthusiasm and some cold hard cash to see this program through. It is inescapable that we must begin to use atomic power plants increasingly in this next decade. Most of you are going to be generating power from atomic sources inevitably in your systems within 20 years. The only question is, how soon?

Now if the industry does not recognize its responsibility and its opportunity in this field, then it is equally clear that public power groups will almost certainly carry the ball, and government will be forced virtually to subsidize atomic power and carry it through. We are to some extent really at the crossroads in this atomic field. We see the combination of a great private atomic industry stretching out ahead of us as an almost certain sound growth with certain unknowns in it, but, nevertheless, the pathways are clear and are manifold. In the foreign field the justification for atomic energy is even more compelling, and some countries like England are in a sense ahead of us already.

If the U. S. industry rises to this possibility in these next few years with sound, well conceived ventures, it is becoming clear in the actions of some public service commissions that they are going to take a friendly attitude toward including the atomic power cost as a proper item in power rate-base considerations. While opinions may differ from state to state about this, the encouraging attitude of a number of state public service commissions is a welcome sign that government and private industry can collaborate in the mutual interests of the country.

So, in this second report to the Edison Electric Institute, it is clear that the atomic age is here to stay. It is inescapably our pathway to future increases in our total energy supply. Many new developments await around the corner, possibly new discoveries, possibly new additives in terms of both fission and fusion types of approach, which may eventually prove interesting as a supplement or as an additive to the atomic fire units started with uranium 235.

The atomic power field is completely wide open with technical improvement possibilities and with financial and cost factors that are already trending in directions that are clearly going to make atomic plants economic in comparison with coal in many parts of the country in the course of the next few years—five years or ten years—if not even sooner depending on the amount of effort we put into it. Atomic power will occupy a major part in your future planning in the decades to come. This is an era of great opportunity and of great responsibilities, and I am confident the electric industry will rise to the challenge of the future.

NAHB Adopts Standard on Service Entrances

THE National Association of Home Builders has unanimously adopted a voluntary standard on electric service entrance capacity which, if followed widely by the country's builders, will give the householder 100-amp capacity in place of the usual 30- to 60-amp capacity. The new suggested capacity agrees with the recommendation of an electrical industry committee that is drafting new national standards of wiring adequacy for residences.

What the home owner will get where this new NAHB voluntary standard is applied by the builder is three-wire, No. 2 service entrance cable or 1¼-in. service conduit containing three No. 2 wires. The greater wire size has direct bearing on the efficiency of an electrical system. At least eight circuits and preferably ten or 12 will be furnished and so designed that a minimum of two of these may be three-wire circuits equipped with circuit breakers or fuses of up to 50-amp capacity.

Treasury Financing and Debt Management

David M. Kennedy
Assistant to the Secretary of the Treasury

An address before the 22nd Annual EEI Convention, Atlantic City, N. J., June 2, 1954

I WOULD like to discuss, to some extent, the aims and objectives and problems of the Treasury. It is not very difficult for me to summarize quickly the aims and objectives. I think I could say that our aim in the Treasury is economy. Our aim is lower taxes. Our aim is to revise the tax burden and our tax statutes so that they will get away from the things that are so irritating and difficult for us now, and we can do that better at a lower level of taxes. It is not quite as easy for me to discuss our problems because we seem to have so many, and I have come to the conclusion that there are no easy problems at the Treasury, perhaps none in Washington.

This Administration has made real progress in cutting government expenditures. I think the record there is very good. Substantial reductions in government spending have been made since this Administration took office about 16 months ago. If you take the budget estimate of the previous administration for the year 1954, the fiscal year ending this June 30, our cut in expenditures is $12,000,000,000. That is a sizeable cut in a relatively short period of time. It takes us through the next fiscal year—$7,000,000,000 up to June 30 and $5,000,000,000 off next year.

The Budget Deficit

The budget deficit was $9,400,000,000 in fiscal 1953. The deficit for the current fiscal year will be between $3,000,000,000 and $3,500,000,000—we hope. Looking forward to fiscal 1955, we estimate that it will be $2,900,000,000. If you add to that a billion dollars of reduction in excise taxes not allowed for in the budget estimate of the present, the deficit would be pushed up to about $4,000,000,000 in fiscal 1955. So the direction has been changed in deficits.

If you change from an administrative budget over to the cash budget, which measures the cash flow to the economy, you find our budget

DAVID M. KENNEDY

this year is approximately in balance on a cash basis. Now it is only because we have been able to reduce expenditures so substantially that we can have a tax reduction such as we are having this year.

Taxes will be reduced in the current calendar year about $7,400,000,000. That includes the Tax Revision Bill now before the Senate Finance Committee, which we hope to pass before long, that effects a $1,400,000,000 tax reduction. The total reduction of $7,400,000,000 includes $3,000,000,000 of individual income taxes that were reduced as of January 1; it includes $1,000,000,000 of excise taxes; and it includes also the $2,000,000,000 estimate of the Excess Profits tax that was permitted to expire.

We haven't done too good a job in explaining this tax program to the public, or to the Congress for that matter. The Tax Revision Bill was not intended as a tax reduction bill. Our whole tax system has grown up over the years by tax increase upon tax increase, one upon the other; it has become a hodgepodge of tax legislation. It was in the year of 1876 that our whole tax structure was revised the last time, and this Administration has had a team of the Treasury working for 16 months with the Joint Committees of the Congress to examine the whole tax structure to see if it couldn't be put into some kind of shape.

We have had criticism that this is a big-business Administration, that the benefits are going largely to industry and not as much to individuals. I don't think you can pull out the parts that go to business and the parts that go to individuals because we are one economy; we are one family. Individuals can't prosper unless business prospers, and business can't prosper unless individuals generally are prospering.

We feel in the Treasury that the tax reductions I cited previously will help materially to ease the impact on the economy of getting back to a lower level of government expenditures. Government spending can only be cut in two ways: we have to lay off someone from the government payrolls, or else we have to reduce the supplies we purchase from industry. These are the two ways we have of reducing government expenditures, and in either case, either directly or indirectly, there is an effect upon employment, and it takes time for an adjustment in the economy to be made. That is why we feel that returning to businesses and to individuals part of the money that the government is saving is going to aid in an orderly transition to a lower level of government expenditures. It will help make new jobs for people who previously received their income from the government.

Working Hard to Balance Budget

It is because of this that we favored the tax reduction even before we attained a complete balance in our budget, which is so desirable, and we are continuing to work almost day and night toward reducing government expenditures and bringing the budget into balance.

But further tax reduction can only come when our level of expendi-

tures has been reduced further. As the government does cut further spending, we hope to pass along to the public, to spend or save for themselves, the money that the government saves through those reductions in expenditures.

The Tax Revision Bill, now being considered by the Senate and the Finance Committee, was never intended as a reduction bill. It was intended as a tax reform measure. For years Congressional Committees, the Congress, and public bodies have been advocating a complete revision of our tax base. Now we find that some of those people who advocated it so strongly are objecting to some of the things that we are proposing. However, under the bill, there will be a tax reduction of about $1,400,000,000.

Corporation Tax Rate

The corporation side of it, however, through retaining the corporation tax rate of 52 per cent rather than permitting it to go down to 47 per cent, will supply about $1,200,000,000 of revenue that would have gone off, and that just about pays the entire cost of the Tax Revision Bill.

Now the provisions of that bill, providing for flexible depreciation allowance and partial relief from double taxation on dividends, we feel, will aid business, particularly small business. These benefits will help businesses to get started and encourage existing businesses to expand, modernize, and create more and better jobs, which only an expanding economy can provide. It will be most helpful, as I indicated earlier, in the transition period to a lower level of government expenditures.

If I were to summarize for you our tax program in this Administration, I would say it is first a reduction of taxes as rapidly as can be justified by reductions in expenditures. Secondly, it is a revision of the tax laws to give millions of taxpayers relief from hardship and inequities and to lessen restrictions that present laws impose on the growth and expansion of the country's economic system.

I'd like to turn for just a moment, now, to Treasury financing. After all, that is my principal interest at the Treasury. I came in largely to work on financing the government and management of debt.

This Administration inherited not only a budget that was completely out of balance and out of control, but also a large public debt that had been built up over two world wars and a long depression. The debt was not only large but it was concentrated in short-term securities. This concentration of the debt so largely in short-term securities has had an inflationary impact on the economy. Under varying conditions it could have a very deflationary effect on the economy. So, realizing the effect on the economy of a very large public debt, we determined to work it out so that the debt would be managed in a way that it would contribute as little to inflation or deflation as possible. In other words, so that it would have a rather neutral effect on the economy.

This means, if we accomplish it, that we have got to spread the debt out over a longer period of time among a larger group of holders or individuals. We appreciate what you in the electric industry are doing in the way of selling savings bonds to your employees at a cost to you. But we feel it is very important that the debt be widely owned by a large number of people in this great country so that they will then have a vital and important interest themselves in what the country is doing.

Financing Operations

It also means that the market that is owned largely by financial institutions, banks, and others should be moved out into somewhat longer maturities. Since the Administration took office we have had ten major financing operations. In seven of these ten operations steps have been made to push the debt out into longer-term securities. This year we have had two major financing operations. In February we were successful in selling $11,000,000,000 of eight-year bonds, largely to banks, but to others as well. Just recently we finished a financing operation where we sold $5,000,000,000 of nearly five-year notes, 1⅞-per cent notes.

Now these two operations, while they were largely in the banking area, tended to extend maturity of the debt and get it in better shape. It also tended to leave money in the hands of financial institutions, largely for mortgages, for corporate financing, and for municipal financing, which we felt was very important in the present state of the economy.

In the months ahead, as we look forward to the future, there will be ample opportunities for us to extend the debt, but this presents a real problem because the march of time runs against us. The Secretary likes to talk about this problem as "The Little Alice Problem"—little Alice in Wonderland, because you have got the volume of debt, as time passes, moving nearer to maturity. Last year a total of $22,000,000,000 of debt moved into the one-year category from beyond one year, just by the march of time. That meant we had to move out $22,000,000,000 to keep where we were. This year $14,500,000,000 moves into the one-year category; so we have got to push out $14,500,000,000 just to stand still.

Monetary Policies

I'd like to turn for a moment now to monetary policies. One of the cornerstones of our honest money program at the Treasury is an independent Federal Reserve System, free to exercise its statutory duty, to restrain inflation, or to assist in combating deflation. In other words, free to gear its credit operations to the economy rather than to facilitate Treasury financing.

We have seen this policy of the Federal Reserve System in operation. In the last part of 1952 and the early part of 1953 we saw the Federal Reserve holding back and not providing the banks with sufficient reserves to provide a base for all the credit that was needed by individuals. Any kind of credit you can think of was being demanded. This heavy demand, bidding against an existing supply, not an increased supply of Federal Reserve activity, caused the interest rates to rise and made it difficult to get money and made it more costly.

Then in the spring of last year, as the money market became very tight and as the estimated needs of business were for greater credit, the Federal Reserve began supplying reserves to the market. In the latter part of the year, after the economy

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Final Report of the Joint Committee on Steam Contamination

Jointly Sponsored by:

Edison Electric Institute, Association of Edison Illuminating Companies, Allis-Chalmers Manufacturing Co., General Electric Co., Westinghouse Electric Corp., Babcock & Wilcox Co., Combustion Engineering, Inc., and Foster Wheeler Corp.

EARLY in 1946 the EEI Prime Movers Committee and the AEIC Power Generation Committee collaborated on a report calling attention to the fact that the deposition of solids on turbine blades in high-pressure plants constituted a problem of considerable magnitude within the industry, and that with all due regard to the capabilities of the many individuals and concerns who had investigated the problem, no appreciable progress toward an explanation or a solution had been obtained. They recommended that a research program on steam contamination be undertaken and that financial support be solicited from EEI, AEIC, turbine and boiler manufacturers, and other interested parties. The project, in its formative stage, envisaged an expenditure of $100,000 over a three-year period.

Arrangements for financing were completed; personnel of the main committee was selected (listed in Appendix A, including subsequent replacements); and, at meetings held in September and December, 1946, proposals submitted by several research groups were reviewed. Armour Research Foundation was selected to undertake this project; its staff and facilities were excellent, and it was completely unfamiliar with the problem, the desire of the sponsor groups being to have a completely fresh approach made.

During the five-year period that the research was in progress funds were appropriated as follows:

Initial appropriation—January, 1947	$100,500
Second appropriation—January, 1950	100,500
Third appropriation—January, 1951	70,350
Total	$271,350

These funds have been expended, the project terminated, and the final report of Armour Research Foundation submitted on April 9, 1952. This termination was recommended by the Joint Committee in concurrence with Armour Research Foundation as being desirable to allow time for all parties concerned to evaluate thoroughly the status of the project before making any recommendations for further work. Before touching on that phase of the report, however, a brief resume of the work undertaken and accomplishments appears to be desirable.

Research Methods and Equipment

The major activities and developments on this project in somewhat chronological order were as follows:

I. Studies of the literature and of the case histories of power plants for orientation purposes and for securing information to formulate a sound experimental program.

II. Studies of surveys of the industry, such as those made by Babcock & Wilcox and Edison Electric Institute, for information pointing to possible solutions of the problem, and conducting additional surveys where desirable toward the same purpose.

III. Plant visits and the collection and analysis of deposits for adding additional information concerning the nature of the deposits.

IV. Research aimed at developing required analytical methods, particularly for silica, needed by industry and necessary for the planned research program. Later expansion of this phase of the program aimed at distinguishing among various forms of silica.

V. Development of new experimental techniques for the research studies:

A. Deposition nozzle and contaminator vessel for rapidly producing experimental deposits.

1. Development of specially prepared plugs for collecting and studying the deposits.
2. Investigations of the effect of various types of polishing and surface preparation on deposition on the plugs.
3. Development of stripping techniques for removal of deposits from plugs for study.
4. Development of electron diffraction methods and procedures for identifying the deposits qualitatively and quantitatively. This project (steam contamination) required development of standard reference patterns heretofore not available.

B. Development of turbine bleedline nozzle for continuously checking the deposition tendencies of steam during normal turbine operation.

C. The installation and operation of equipment referred to in A and B at Fisk Station, Commonwealth Edison Co.

D. Small-scale high-pressure bomb studies leading to design, construction and operation of the solubility bomb and controlled furnace for determining the solubility of silica in saturated steam in a non-flow system.

E. Development of apparatus and techniques for controlled injection of materials into the steam.

VI. Studies and investigations of devices and techniques for estimating mechanical carryover.

VII. Development of apparatus for ionization of steam by corona discharge.

VIII. Major experimental studies.

A. Used contaminator and deposition nozzle to study tendency for silica to deposit on 18 different metals and on over 20 treated or coated surfaces.

B. Used injection equipment to study mechanism of deposition and effects of several injected materials. These studies led to later conclu-

sions regarding mechanism of silica deposition due to nucleation.

C. Solubility bomb studies for determination of solubility of silica in saturated steam at various pressures.

D. Tests on mixed bed ion exchange units to study removal of silica from make-up water and condensate.

E. Investigated nucleation of silica by ionization of steam using corona discharge and radioactive isotopes.

Results

In the proposal submitted to Armour Research Foundation, the problem was stated as follows: "To determine the causes of deposition of solids on turbine blades in high pressure power plant operations and subsequently to control or eliminate this nuisance." The research completed has developed the following direct answers to that problem:

I. Silica deposition (and probably the deposition of other contaminants in steam) occurs because of a phase change releasing soluble or vaporized silica from the steam directly onto the blading by nucleation.

II. Deposition may be prevented by nucleating the silica in the steam space, thus competing with the turbine blading as a nucleating agent.

III. Silica may be nucleated by fine particles. Steam which has been ionized by corona discharge or isotope radiation will also nucleate silica; in this case, no solid matter is added to the steam.

In addition to the foregoing, the research program:

A. Resulted in the development of analytical methods for determination of soluble and total silica in very low concentrations. These methods were presented at the 1951 ASME Annual Meeting and have had wide industry acceptance.

B. Contributed technical data for papers on electron diffraction and film stripping techniques, important technical contributions that may become of practical value to the utility industry.

C. Demonstrated that silica is deposited in amorphous form.

D. Developed a turbine bleed-line nozzle for use in plants to check the deposition tendencies of steam.

E. Demonstrated that the deposit problem could not be solved by substitution of other metals for turbine blades.

F. Obtained data indicating that various surface treatments and coatings on blades did not reduce silica deposits except in the case of Teflon. This material might have some application for the purpose at temperatures below 600F.

G. Obtained the following information through use of the injection equipment:

a. Finely divided suspended silica in steam does not deposit.

b. The direct answers I, II, III, above.

c. That fluorides cannot be used to solubilize the silica.

H. Proved in solubility bomb tests that silica is soluble or vaporized in saturated steam and, therefore, that improved boiler baffling cannot yield completely silica-free steam.

I. Studied methods of removal of mechanical entrainment by electrostatic, supersonic, centrifugal, and other means.

J. Demonstrated that modern mixed-bed ion-exchange units were capable of removal of silica from feedwater or condensate down to 0.01 ppm or less.

Summary and Recommendations

The final report submitted by Armour Research Foundation stated that "the evidence is overwhelmingly in support of the theory that deposition on turbine blades occurs by nucleation and that prevention of deposits can be accomplished by nucleating the silica in the steam space." It recommends that action be taken immediately to institute a research program for fully investigating nucleation with the ultimate objective of developing a device or procedure for controlled nucleation during normal turbine operation and estimated that two years' time and $100,000 would complete the project.

The committee is in substantial concurrence with the opinions and conclusion regarding the mechanism of deposition expressed by Armour Research Foundation. Before concurring in its recommendations as to future research, however, the committee sought advice and guidance from personnel familiar with nucleation theory at Argonne National Laboratory, University of Chicago, and from the research laboratories of several manufacturers.

The summary opinion from these sources is to the effect that (1) injection of nucleating agents, either solid particles or ions, into steam to control silica deposition in turbines does not seem likely to be practical or successful and (2) the control of deposition by maintaining very low silica concentrations in the system, such as its removal by ion exchange, is considered to offer considerable hope of success.

Further Group Research Curtailed

It is now approximately a year since these opinions were given the committee. Meanwhile, considerable information from a large number of plants using a variety of methods for maintaining very low silica concentrations in the system indicates that deposition control by such techniques is both effective and economical. Continuing research and operating studies by equipment manufacturers and utilities aimed at this method of control appear to be the best present method of attacking this problem, and it is, therefore, the recommendation of this committee that no further group research be done on the subject of steam contamination as applied to turbine blade deposits.

APPENDIX

Personnel of Joint Committee on Steam Contamination

Representing Edison Electric Institute

J. N. Landis, Consolidated Edison Co. of New York, Inc.; Dr. S. F. Whirl, Duquesne Light Co.; S. T. Powell (Associate Member), Chemical Engineer, 330 N. Charles St., Baltimore, Md.; *Secretary*, H. C. Miller, Testing Laboratory, Public Service Electric and Gas Co.; *Chairman*, C. C. Whelchel, Buffalo Niagara Electric Corp.

Representing Association of Edison Illuminating Companies

A. E. Grunert, Commonwealth Edison Co.; J. N. Landis, Consolidated Edison Co. of New York, Inc.; E. H. Tenney, Union Electric Co. of Missouri; C. C. Whelchel, Buffalo Niagara Electric Corp.; M. K. Drewry, Wisconsin Electric Power Co.; I. L.

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Personals

MR. CISLER

MR. NAUGHTON

MR. FITE

The retirements of two executives at The Detroit Edison Co. and the appointment of their successors have been announced.

Prentiss M. Brown, Chairman of the Board, and **Arthur S. Albright,** Executive Vice President, have retired. **Walker L. Cisler,** President, has become principal executive officer of the company with continuation of his present title, the duties and responsibilities of the chairman of the board having been consolidated with those of the president. **Charles R. Landrigan,** Vice President, succeeds Mr. Albright as Executive Vice President.

Mr. Cisler joined Detroit Edison in 1943 as chief engineer, having previously served with Public Service Electric and Gas Co. for 21 years after graduating from Cornell University. In World War II he served overseas as a U. S. Army colonel, returning to Detroit Edison in 1945. He became executive vice president in 1948 and president and director in 1951. Active in many business and industrial organizations, he is a member of the Institute's Board of Directors and Executive Committee and is chairman of its Electric Power Survey Committee.

Mr. Landrigan started with Detroit Edison in 1912 in the Production Department at the Delray Power Plant. He spent some time in the Construction Department and was transferred to the Control Department, where he became assistant controller in 1932, controller in 1949, and vice president in 1953.

Mr. Brown, presently chairman of the Mackinac Bridge Authority, is a former Congressman, U. S. Senator, and one-time director of OPA. He joined Detroit Edison in 1944 as chairman of the board after resigning from the OPA post. A lawyer by profession and active in public service, he has served on the Institute's Advisory Committee. He will continue to serve Detroit Edison as a director.

Mr. Albright joined Detroit Edison's Statistical Department in 1912 after graduating from Ohio State University. He served as superintendent of meters, acting chief of research, controller, treasurer, and vice president before becoming executive vice president in 1953.

Edward M. Naughton, Vice President and General Manager of Utah Power & Light Co., has been elected President of the company, succeeding **George M. Gadsby,** who will continue as a Director and Chairman of the Board. At the same time, **Joseph E. Cushman,** Commercial Manager, and **David D. Moffat, Jr.,** Assistant to the President, have been made Vice Presidents.

Mr. Naughton, a 1923 mechanical engineering graduate of the University of Notre Dame, has been associated with the electric industry for 29 years, including six months' work for the government in 1952 as director of the Engine and Turbine Division of NPA. Following graduation from Notre Dame he attended the post-graduate school at Westinghouse Electric Corp. before joining Texas Power & Light Co. in 1925. He joined UP&L in 1935 as superintendent of steam-electric generating stations. In 1942 he was made assistant to the vice president in charge of the Engineering, Construction, and Operating Department and in 1950 was named assistant manager of the company. He became vice president in 1953.

Mr. Gadsby, who served as EEI President for the year 1951-52, has been chief executive of Utah Power & Light for the last 25 years. A native of Ohio, he received an M.A. degree from Marietta College in 1907 and a B.S. degree from MIT in 1909. After serving with the Warren Water Co. he joined West Penn Power Co. in 1918, becoming president and general manager in 1927. In 1929 he joined Electric Bond and Share Co., moving to its subsidiary, Utah Power & Light, that same year as president.

Mr. Cushman, who became commercial manager in February of this year, has been with UP&L since 1912. Prior to his last post, he served successively as groundman, salesman, troubleman and lineman, district representative, division superintendent of lines and service crews, division manager, and assistant to the vice president.

Mr. Moffat, with UP&L since 1929, attended the University of Utah and the University of California, graduating from the latter in 1929. He later received a master's degree from MIT, through a fellowship. He started with the company as a salesman and served successively as lighting specialist, division sales manager, and rate engineer before entering the armed services in 1942. Returning to Utah Power & Light in 1946, he became research engineer, staff engineer, and assistant to the vice president before being named assistant to the president in 1952.

Robert H. Fite, Vice President and General Manager, Florida Power & Light Co., has been elected President and is to continue as General Manager. At the same time, **McGregor Smith,** Mr. Fite's predecessor, was elected Chairman of the Board, a post heretofore not filled.

Mr. Fite joined Florida Power & Light in 1929, three years after graduating from Vanderbilt University as an electrical engineer. He was made a department head in 1927 and general sales manager in 1934. In 1936 he left FP&L to join Ebasco

Services Inc., where he became head of the Sales Department in 1939. In Washington during World War II, he helped co-ordinate the operations and expansion of many utility companies with the war production plans of various branches of the government. He returned to FP&L in 1945 as commercial vice president and director, becoming general manager in 1950.

Mr. Smith served on the Tennessee Railroad and Public Utilities Commission for five years before joining South New Orleans Light & Traction Co. as general manager in 1926, a year before it was consolidated with other companies to form Louisiana Power & Light Co. Within ten years he had become president and general manager of the Louisiana utility. In 1939 he resigned to join Florida Power & Light as vice president. He became president and general manager later that year.

Horace P. Liversidge, Chairman of the Board of Philadelphia Electric Co. and a member of the Institute's Advisory Committee, has been elected Chairman of the Board of Trustees at Drexel Institute of Technology, succeeding **A. J. Drexel Paul, Sr.,** grandson of Drexel's founder.

Winthrop E. Mange and **Otto W. Manz, Jr.,** Assistant Vice Presidents of Consolidated Edison Co. of New York, Inc., have been elected Vice Presidents. Mr. Mange is to be in charge of industrial relations and Mr. Manz is to be responsible for testing and distribution operations.

Mr. Mange joined New York State Electric & Gas Co., part of the then Associated Gas and Electric System, as an engineer immediately after graduation from Cornell University in 1922. Four years later he joined Staten Island Edison Corp. as assistant general manager, serving later as general manager of several companies in the AG&E system. He returned to Staten Island Edison as vice president and general manager in 1937 and became president in 1938. When Staten Island Edison was acquired by Con Edison in 1951, he was appointed assistant vice president.

Mr. Manz, a 1923 graduate of the University of Pennsylvania, joined Brooklyn Edison Co., now part of Con Edison, as an engineering assistant. From 1943 to 1946 he was on loan to the Carbide and Carbon Chemical Corp., supervising the construction and operation of a new electric generating station at Oak Ridge, Tenn. Back at Con Edison in 1946 he joined the System Operation Department, becoming manager of it in 1950. He has been assistant vice president since 1952.

Treasury Financing and Debt Management

(*Continued from page* 264)

started to turn down a little and there was shown some need in the economy for a greater supply of reserves, the Federal Reserve inaugurated what it terms a policy of active ease, intended to give a climate from a credit standpoint that would encourage business to go ahead and provide the jobs and the goods that we need to keep the economy going. In these circumstances we have seen the interest rate decline very sharply as the supply of credit exceeded a lessened demand for credit.

We now find, as we look over the credit structure, that there is ample credit in all fields, for individuals, businesses, home builders, purchasers, states, and municipalities. The municipal market seems to be a little congested, but there is ample credit through the country to take care of that under the policy of the Federal Reserve.

This change in direction of policy has been criticized by some as being a return to the easy-money policy of the Twenties, or the war easy-money policy. Actually, it is not that. It is a flexible policy designed by the Federal Reserve to promote the public interest, not dominated by the Treasury or anyone else.

I spent a number of years at the Federal Reserve, some 16 years, and I knew the secretaries of the Treasury from Morgenthau on, personally. I have never seen the relationship between the Federal Reserve and the Treasury on a better business-like basis than it is at the present time, neither trying to dominate the other, each sitting around the table discussing common problems. I believe that is the way we should run this government.

The aims and objectives, as I said in the beginning, are fairly easy to state and summarize: economy, lower taxes, and honest money. I believe these aims are being accomplished. The transition to a lower level of government expenditures is taking place rather smoothly. We find public response and support of this program most reassuring to us at the Treasury.

A foundation based on free enterprise, removal of handicaps and restrictions, and sound realistic programs is laying the groundwork for the healthy long-term growth and prosperity of our country. We look forward to the future with confidence.

Steam Contamination

(*Continued from page* 266)

Wade, Public Service Co. of Northern Illinois; V. L. Stone, Commonwealth Edison Co.

Representing Turbine Manufacturers

C. B. Campbell, Westinghouse Electric Corp.; E. H. Horstman, Allis-Chalmers Manufacturing Co.; Glenn B. Warren (represented by P. H. Knowlton), General Electric Co.

Representing Boiler Manufacturers

Martin Frisch, Foster Wheeler Corp.; Alfred Iddles (represented by W. H. Rowand), Babcock & Wilcox Co.; John Van Brunt, Combustion Engineering, Inc.

NOTE: C. C. Whelchel served as Chairman from August, 1946 to July, 1947; A. E. Grunert served as Chairman from July, 1947 to May, 1949; V. L. Stone served as Chairman from May, 1949 to date.

PERSONNEL OF STEERING COMMITTEE

Chairmen—C. C. Whelchel, A. E. Grunert, V. L. Stone.

Secretary—H. C. Miller.

Representing AEIC — The Chairman.

Representing EEI — Dr. S. F. Whirl.

Boiler Manufacturers—W. H. Rowand.

Turbine Manufacturers — P. H. Knowlton.

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A. B. MORGAN, *Secretary and Assistant Managing Director* 420 Lexington Avenue, New York, N. Y.

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Farm Section, E. D. SMITH.....The Dayton Power and Light Co., Dayton, Ohio
Industrial Power and Heating Section, MAXWELL COLE.....Philadelphia Electric Co., Philadelphia, Pa.
Residential Section, R. J. MILLER.....The Cleveland Electric Illuminating Co., Cleveland, Ohio
Special Service Section, J. M. STEDMAN.....Pennsylvania Power & Light Co., Allentown, Pa.

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Transmission and Distribution, J. W. ANDERSON.....Philadelphia Electric Co., Philadelphia, Pa.

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Area Development, W. I. DOLBEARE.....Virginia Electric and Power Co., Richmond, Va.
Atomic Power, EDGAR H. DIXON.....Middle South Utilities, Inc., New York N. Y.
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Electric Power Survey, WALKER L. CISLER.....The Detroit Edison Co., Detroit, Mich.
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Industrial Relations, F. R. RAUCH.....The Cincinnati Gas & Electric Co., Cincinnati, Ohio
Insurance, W. O. RANDLETT.....Virginia Electric and Power Co., Richmond, Va.
Legal, T. JUSTIN MOORE.....Virginia Electric and Power Co., Richmond, Va.
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Prize Awards, HARRY RESTOFSKI.....West Penn Power Co., Pittsburgh, Pa.
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Research Projects, STANLEY STOKES.....Union Electric Co. of Missouri, St. Louis, Mo.
Statistical, W. W. GODARD.....The Cleveland Electric Illuminating Co., Cleveland, Ohio
Transportation, D. K. WILSON.....Niagara Mohawk Power Corp., Albany, N. Y.